

WE ARE AT WAR

*Address by Sir Alfred Herbert, K.C.B., Hon. M.I.P.E.,
given to the Institution, Leicester Section.**

This address is a clarion call to prompt and vigorous action on the "industrial front." It calls for fearless abandonment of our most cherished institutions wherever they obstruct the vast flow of munitions and mechanised equipment which must go to our gallant fighting forces. The scandal of those vital machines which work only twelve instead of twenty-four hours a day is exposed. The problems of labour and night shifts, dilution of skilled labour, and the extensive introduction of female labour are dealt with. The amazing capacity of women for work in engineering workshops is amply illustrated, and training schemes designed to direct this natural ability to the nation's advantage are mentioned. It is suggested that the use of substitute materials and a stricter measure of economy would considerably relieve material shortage. An appeal is made for a rational attitude toward priority. In the discussion which follows the paper questions of compulsory labour and of a deferred payment scheme to meet the post war depression are raised.

I AM always happy to address a Leicester audience and particularly so to-day when my audience is composed in the main of members of the Institution of Production Engineers. Leicester is my native town. I was educated and served my apprenticeship here, and although fate decreed that my life work should be carried on elsewhere, I always retain the happiest memories of your town and a deep regard and esteem for many Leicester friends and associates.

I, too, am a member of the I.P.E. and in its early days I was honoured by being your President. I should like to express my hearty congratulations on the wonderful progress that your Institute has made since those days under a succession of able Presidents and with the energetic and most capable guidance of your General Secretary.

This evening, through the kindness of your Council, I have been sumptuously entertained. If therefore I should fall asleep in the middle of my talk you will understand the cause (laughter) and will make due allowance.

In choosing the title of my address I was influenced perhaps by our very logical French allies, who, when anything goes wrong, and you complain, just shrug their shoulders and say "Que

* This report has been extended to include material which was to have been given in an address by Sir Alfred Herbert to the Birmingham section of the Institution of Production Engineers on May 29. In consequence of the urgent demands upon the time of all production engineers, caused by the national emergency, the meeting was cancelled. All insertions are preceded by a paragraph mark.

voulez-vous ? C'est la guerre " which may be translated freely as "What do you expect ? We are at war."

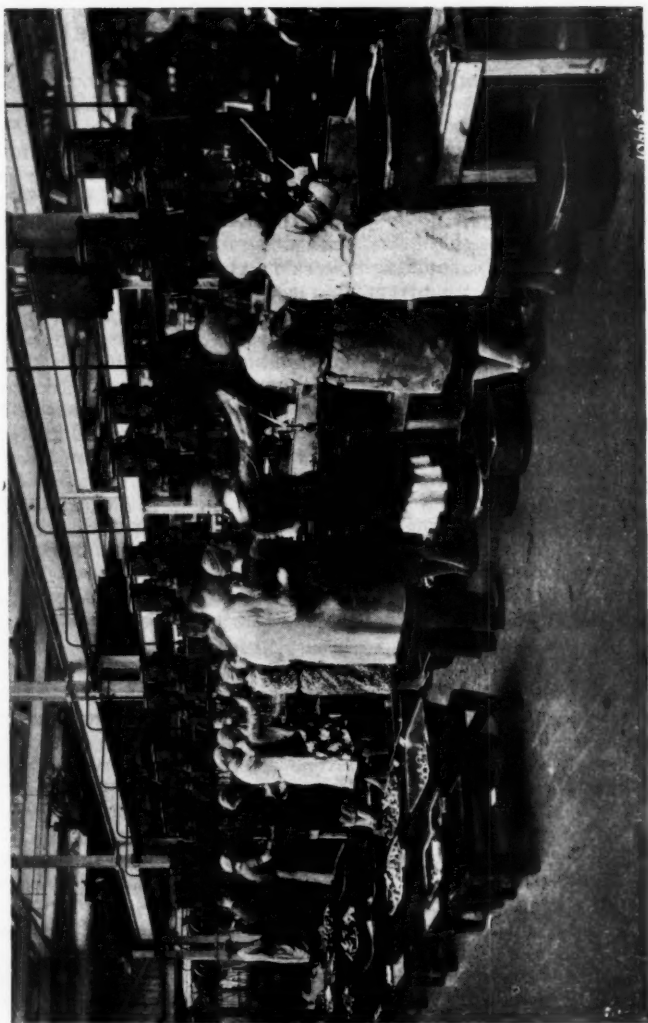
It is the job of every business man, and particularly of every engineer, to seek the truth and to speak the truth, not only in technical and commercial matters but in everything he undertakes. This is one of the many privileges which we still enjoy in sharp contrast to our enemy, and I intend to avail myself freely of this privilege in my address to you.

It will be my duty to make certain criticisms and to give certain suggestions, but I hope you will acquit me of any feeling of self satisfaction. I am fully conscious of the many shortcomings of myself and of my company. We are doing our best, but much still remains to be done, and we are still very far short of the attainment of our ideals. Criticism, when it is intended to be constructive, is not in my experience generally resented. It is indeed one of the proofs of character for a man to be able to take friendly and helpful criticism in the right way. It is good for all of us to concentrate on our own failures and inefficiencies ; that which is good and satisfactory may well be left to take care of itself.

Instead of the German greeting "Heil Hitler" I should like our English greeting to be "We are at war." We are fighting with two armies—first our sailors, soldiers, and airmen ; they realise that we are at war. They have given up their homes, their work, their earnings, and hardship and privation is their daily lot ; already many have suffered wounds and a growing number have given their lives. The toll is increasing every day. Our second army consists of all engaged in war industry—you and I are members of it. Our job is to supply the fighting men with all they need to kill their enemies and to protect themselves and us. If our defences are inadequate, we too shall be called upon to suffer wounds and death. But so far we have made few sacrifices, if any, except the discomforts of the black-out and the increased taxation which we gladly pay. We who belong to the industrial army must give our utmost. Anyone who does not do his fair share is helping the enemy ; anyone who by word or deed wilfully obstructs or delays progress may well be guilty of his brother's blood.

In the early stages of the last war, I watched the convoys of wounded arriving in London. How many of these, I asked myself, have suffered because we were short of guns, shells, and 'planes ? Once more the convoys are coming in to-day. Let us pray that it is not from the same cause.

Candidly, gentlemen, when I see how placidly some of our citizens are carrying on I cannot help asking myself in all seriousness if they really *do* grasp the fact that we are at war and that our implacable enemy is the most formidable nation in the world. Germany has a population far greater than our own. This population from its youth upwards has been nurtured, drilled and trained in long



During the last war women came forward in large numbers to fill the gaps in engineering production.

and determined preparation for fighting, and to this end every other consideration has been subordinated. "Will you have guns or butter" was asked years back, and the answer invariably has been "GUNS."

German leadership has, for years, been welding the whole nation into an animated war machine. Our enemies possess scientific and mechanical resources of the highest order, and a productive capacity which has been developed and extended far beyond that of Britain and her allies combined, though by no means beyond what we can attain if the resources of our Empires and Colonies are brought to full fruition.

Our enemy is waging a total war against us and has light-heartedly cast aside every humanitarian restraint. It is part of his policy to break without compunction the most solemn undertakings, to employ to the full the devilish arts of propaganda and to look upon treachery, corruption, and betrayal as his normal weapons. We have the clearest demonstration of his aims and methods in the treatment he has already applied to Austria, Czechoslovakia, Poland, Danzig, and which he is now in turn applying to Denmark and Norway, and so long as other neutrals refuse to help one another with their combined strength, they are likely to fall one by one like ripe cherries.

Do we realise that in the background lurks that great power Russia, with which Germany has by the unhesitating sacrifice of the few principles which it at one time treasured, made an unholy and mysterious agreement? Do we forget that Italy and Japan (which were our close allies in the last war) are at present neutral, and that their neutrality can hardly be characterised as benevolent?

Have we forgotten that America, which placed unlimited industrial and financial resources at our disposal in the last war, and which finally joined us in an armed alliance, is no longer definitely on our side, though we are still dependent on her for much of our war material on a strictly cash and carry basis? Have we appreciated fully the enormous financial strain of meeting these American payments with prices continually advancing and with the growing difficulty in providing the necessary dollar exchange, which has gone against us very heavily since the war broke out?

Have we realised that there is no hope of a negotiated peace, and that we have our backs to the wall and must fight it out to a finish?

We are reaping what we have sown and the harvest is a bitter one. During the years of peace we neglected every branch of our defence in the vain hope that other nations would follow our example, and it took us years to wake up to the fact that so far from doing this they were making the most of the opportunity we had given them to overtake us in every war-like preparation. We finally reached

the point when our adversaries believed that we neither could nor would fight under any provocation—they are learning that they made a grave mistake.

It is true, of course, that as the sands were already beginning to run out, we stirred a little uneasily in our slumbers, and began to make some belated attempts to strengthen our position. We, and our allies, were never apparently of the same mind at any moment, and we let every opportunity of checking Germany's encroachment slip past us. Statesmanship both here and in France was at its lowest ebb, and then, when every hope of appeasement had failed, and when the last German pledge had been broken we suddenly realised that war stared us in the face, and got busy with evacuation, A.R.P., and vigorous if belated attempts to achieve some measure of self-defence were made.

At the outbreak of war we all believed that it would be brought home to us immediately and on a devastating scale. So far the war (and I think this is true of every war in which we have been engaged) has taken a course that was entirely unexpected; the threatened attack on our cities and our homes has been deferred; the terrific fighting which we anticipated on Franco-German borders has not yet developed, but the threats still remain and nothing justifies the assumption that the threats will not have to be faced. The brunt of the fighting so far has been borne by the navy and the air force, and their achievements have already convinced our enemies that we were not lacking either the will or the ability to fight.

Have we realised the enormously increased demand on industry which arises from the mechanisation of our armies and the great expansion of our Air Force?

Have we taken into account that the aeroplane of to-day both in material and man-power makes enormously greater demand than the simple and cheap machines of the last war?

Have we realised too that so far our expenditure of ammunition and our losses of war material have been almost negligible compared with the demand that will be made on us when the threatened clash materialises?

Have we formed any conception of the immense quantities of ammunition, consumed by the quick-firing weapons with which we are equipped?

Have we realised the rate at which quick-firing weapons deteriorate and require replacement and repair?

Is it stamped on our minds that every man taken of necessity from industry to join the army counts two against us on the balance sheet? As a workman we lose him; as a soldier he has to be equipped.

It cannot be denied that a democracy, with all its advantages of

individual liberty, must of necessity be a less efficient system for carrying on a war than a dictatorship. Under a dictatorship decisions are made rapidly and are put into force immediately, while in a democracy weeks and months are spent in arguments and persuasion, and action lags behind. It is often only under the dreadful stimulus of heavy losses and threatened defeat that united and energetic action is taken.

As manufacturers our course is clear. It is our duty not to wait for the Government to provide either stimulus or initiative. It is on the force of public opinion and on individual effort that we must depend for results.

Without the utmost co-operation of industry, our forces cannot win the war. In some form or other, not only engineers, but every form of industry is called upon to contribute to the needs of our fighting men. Nor must we lose sight of the immense importance of our export business, for how can we hope to pay for the goods we are buying abroad unless our exports are increased?

Idle Machines.

And now from these more general considerations let us come down to the every day facts with which we as engineers are confronted at every hand. It is a fact that although there are some shining examples to the contrary, at least half of the productive plant of this country lies idle at night. Let us assume that the present productive capacity of the machinery working by day is represented by 100. If half of this machinery is working at night we can represent that by 50. We get a total of 150 representing our present total capacity. If the whole of the machinery could be employed at night 50 points would be added to the total, making it 200 against the present 150, an increase of $33\frac{1}{3}\%$, and this increase could be achieved without the expenditure of any additional capital.

Surely the importation of masses of new machinery should be reduced by the full employment of that which we already have. If we cannot find labour to work our existing machines how shall we find it to work the new machines which are pouring into the country?

¶ Large quantities of new machines are, of course, necessary and will continue to be necessary, but it is clear that to the extent to which we make continuous use of the machines we already have, to that extent will the demand for additional new machinery be reduced.

Is it fully realised that all machines which are now at work are equipped with jigs, tools, cutters, and the like while every new machine put down is useless until it has been similarly equipped. The expenditure for equipping a machine for manufacturing pro-

cesses frequently amounts to a considerable percentage of the cost of that machine, and all this work has to be carried out in our toolrooms where conditions are more congested than in any department of our works and where dilution of labour is most strongly resisted. Surely, this is a cogent argument for first making full use of what we have already.

Labour and Night Shifts.

Why are our machines standing idle at night? The answer is that the necessary labour cannot be obtained by ordinary means. But is this a reason why we should accept the present intolerable position? Very definitely, I say that it is not, but that the very difficulties that we have to face should stimulate both employers and workers to rectify the situation, to abandon old traditions, to sacrifice privileges and to get on with the job.

¶ Ever since the beginning of the war I have been a voice crying in the wilderness, trying—with little success—to rouse public opinion to the need for sweeping away all peace-time restrictions, whether imposed by the Home Office or the Trade Unions, so that full use should be made of the only available workers, of whom thousands still remain unemployed. I am ashamed that I did not act sooner and with greater energy for I have burned into my memory the failures and obstructions which nearly lost us the last war. Many employers are at last realizing the position and are up and doing, but the problems have not been faced boldly and squarely even now.

I would remind you that our unemployed still stand at the staggering total of something like a million and a quarter, but in addition to those registered unemployed people there are thousands of men and women throughout the country not normally engaged in manual work who came forward during the last war and gave their services with the greatest enthusiasm and success, and who will gladly do so now. In the last war it is true that women were not fully employed until after two or three years of catastrophe and bloodshed, but they were employed in the end. Is this war any less serious than the last? To me it seems infinitely more serious, and that the need for breaking down every prejudice and removing every obstacle is greater than at any time in history.

In August of last year an agreement was arrived at between the Engineering Employers' Federation and the A.E.U. which provides the machinery for dilution. This agreement was made under the shadow of war, but so far as I know it still stands though war experience has taught us that it needs modification and simplification to enable the process of dilution to proceed with the rapidity which is urgent in to-day's conditions and without the long and

tedious consultations, discussions, and conferences by which our management has been wearied and worn out.

The leaders of the Labour Party have again and again expressed their full determination to support the Government wholeheartedly in carrying on the war and to make such sacrifices of regulations and restrictions as may be necessary to this end, with a very natural provision that after the war peace-time practice should be restored. I understand that in many districts these undertakings are carried out without serious opposition, and from what I hear conditions in Leicester are very favourable in this respect. In other districts difficulties have been very great and advantage has been taken of every technicality to retard and delay dilution by the introduction of alternative and substitute labour, whether male or female. In Coventry these difficulties have been great.

¶ We nearly lost the last war for lack of munitions and we are risking defeat in this war for precisely the same reason. Then we had some excuse for we had no experience of modern war in its full intensity and we had had little time to prepare. In this war the bitter lesson should have been fresh in our minds. We had eighteen months, at the least, of warning that war was coming, and we have now had nine months of actual war, and yet it is only during the last few days—and then only as the price of a political bargain—that the air at last shows some signs of being cleared.

¶ Do not let us imagine that Government control in itself will accomplish miracles. All it has done so far is to remove the major obstacles, which it had hitherto allowed to pile up against progress. The real work of production will go on, and must go on, under the management of our business men and engineers, who alone by experience and training have some knowledge of how results can be obtained. God forbid that the Government should attempt to introduce into industry any of the amazing complexities of Civil Service administration.

During a half century of work the relations between my company and the Trade Unions have been of a friendly character, and on the whole we have rubbed along together fairly well. We have agreed with each other when agreement was possible and when it was not, we have agreed to differ, and in peace time we are happy to observe all the procedures and comply with every stipulation which is arrived at by our respective leaders. But in to-day's conditions when our lives and liberties are at stake it is time, surely, to plead for a temporary removal of every obstruction. I admit, with satisfaction, and with full appreciation, that definite progress during the last three or four months has at last been made, but we have already lost time which cannot be regained. It is not too much to say that Trade Unions have it in their power by full co-operation

to win the war and greatly to reduce its length, with the consequent saving of life and suffering to many thousands, not only of our fighting forces, but of the women and children in their own homes. On the contrary, if they adopt a policy of delay and of obstruction, they have the power to make the war drag on, and even to lose it. I wonder how many peace-time privileges would be retained under German domination?

We have heard, until I am tired of it, that "Time is on our side." That if we go quietly on and don't worry unduly all will be well in the end. But time is not on our side, unless we use every minute of it, starting now.

¶ Whether the Government control us wisely or unwisely our duty is clear. We must give the last ounce of our effort towards the end which we recognise as all important; looking on all questions of profits and of taxation as of little present account, for "all that a man has he will give for his life."

Dilution of Skilled Labour.

There is practically no skilled labour unemployed. Our newspapers are full of advertisements for skilled labour of every kind. The Government has taken powers to prohibit the insertion of such advertisements, and it is to be hoped that before long they will exercise these powers, for the effect of these advertisements is simply robbing Peter to pay Paul, and the total effort is hindered rather than helped.

It cannot be denied that a large proportion of skilled workers are being engaged on work which is not skilled in the real sense and which, given goodwill on both sides, is perfectly capable of being dealt with by semi-skilled or unskilled labour after a very brief period of training. Thus, the skilled man can be freed from drudgery and left to devote himself entirely to those jobs which are worthy of his experience and ability and which alone can be performed by skilled craftsmen. As this new labour is introduced, great opportunities are provided for grading up the skilled men. Journeymen can be promoted to chargehands, chargehands to foremen, foremen to managers, and so on. You remember the story of the well-organised firm which, when its chairman resigned had nothing to do but to engage a new office boy and move everybody up one.

¶ After more than half a century of close contact with British labour, I here and now record my highest appreciation of its sterling qualities, its loyalty and its ability. But labour must have vision, and in the past this has been largely and often deliberately denied to it. Now that the gravity of the hour has at last been realised by every one of us, I have no fear of difficulties with labour and I am confident that every worker will put his full effort into the task which lies before him.

Instead of being asked to make sacrifices of peace-time regulations labour has, up to now, been encouraged to try to uphold them, and it has become entangled in endless discussions which have stopped progress. If the Government had known the fine qualities of our workers as I know them, it would have said, "This is a time for sacrifice and for service to the full," and I know the sacrifices would have been made willingly and joyfully just as, indeed, they are being made now at this eleventh hour.

¶ I get many letters from older men—some skilled, some unskilled—telling me of the difficulties they find in obtaining work, which they are most anxious to do, because of their age. I believe that no man who is sound and sensible should be refused work merely on the ground that he is over fifty, or for that matter over sixty.

Training.

It is obvious that before anyone can undertake even the simplest job without previous experience a period of training is necessary. This training should be confined to instruction in the routine jobs, mainly of a repetition character. It can be carried out either in a special training department, which every works of any importance should establish, or it can be carried out in the actual shops by putting the pupil on to an operation under the close and personal care of the foreman or chargehand and with the full help and encouragement of his shop mates.

Those who have not made the experiment will be astonished at the rapidity at which simple jobs are picked up, and there are few repetition operations on the drilling machine, the turret lathe, the milling machine, or the simple grinding machine which cannot be learnt in a fortnight at the most.

Under the stimulance of piecework, progress is rapid and earnings are surprisingly high. In addition to the training in the workshops there are other facilities in existence which should be fully used. The Government has already established a very large number of excellent training centres throughout the country—one of the best of them you are already familiar with for it is in your own town. I have seen the work carried on in that Institution and have been greatly impressed by its thoroughness, but the course of training is too long and too elaborate for war time conditions. I believe the Government is beginning to recognise this and that the training is being modified in such a way as to reduce the time occupied by each trainee and consequently largely to increase the number of people dealt with.

In many cities excellent technical colleges exist with skilled staffs and adequate equipment of machines. All these colleges should undertake, without loss of time, the rapid training of unskilled labour

instead of the elaborate and long drawn out courses, which are excellent in peace time. The instructions should be concentrated on simple jobs and should be limited to a fortnight or at the most a month.

One of my many failures was an attempt to get the Coventry Technical College, which is an excellent institution with first rate equipment to undertake training. I first began my attempt in January. Every difficulty was experienced owing to the reluctance of the educational sub-committee to move. Difficulties were raised on the score that no suitable instructors were available, that no material could be obtained, and generally speaking, that nothing could be done. Finally, we made a proposal by which we undertook to pay a rent to the technical college for the use of their machinery, to provide instructors, together with the necessary material and tools, and to find the trainees and to give them subsequent employment as soon as they were trained. The proposal was approved by the educational sub-committee, but this committee insisted that the proposal should be subject to the approval of the local Trade Unions. To what extent the local Trade Unions are concerned with the management of technical colleges I have no idea, but the Trade Unions turned the proposal down flat, and succeeded in completely obstructing any progress until now. This is not the spirit that is calculated to win the war. I have always been proud of Coventry but I lost my pride on that day.

I hear with the greatest satisfaction that technical colleges generally are taking a very different view of the situation, and I confidently believe that in the very near future an immense amount of valuable training will be carried out by these institutions. Even Coventry will, at last, rise to the occasion, and I hope your technical college here, and the one at Loughborough, is facing this urgent problem. Normal peace-time instruction must be abandoned and the decks cleared for a great effort.

¶ In many engineering works the excellent practice of allowing apprentices to have time off in the day-time in order to attend technical classes has been continued and probably continues to-day. Now these lads must share in the general sacrifice. They must give up their day-time classes during the war and keep their machines running. This has already been put into effect in the case of my own company, and I regret that the step has been so long delayed.

Women's Work.

When I was Controller of machine tools during the last war I was frequently asked by employees and unionists to give some definition of women's work, and I was confronted even with masses

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of parts of machines, and asked whether they were women's work or not.

I always refused to discuss details and contented myself with this definition—women's work is the work that women can do, and this can only be determined by giving them a chance to try. This, I think, remains as true to-day as it was then.

Until the last war comparatively few women were engaged in engineering, but "Needs must when the devil drives" and the devil drove us hard enough then to bring women into almost every branch of engineering in continually increasing numbers, not with the idea of reducing men's employment, but to fill the gaps in production which were occasioned by the continual drafts of men into the Forces.



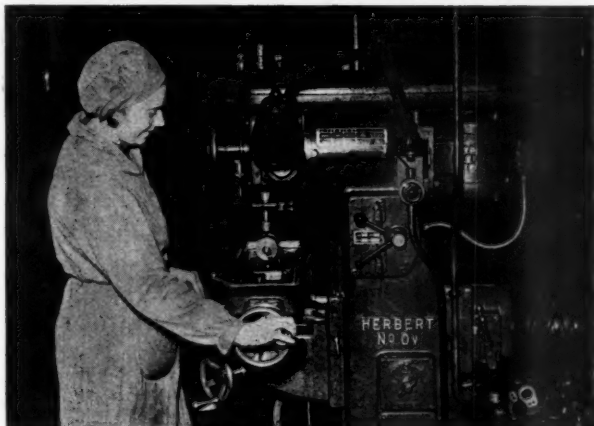
The response that was received from women was extraordinary and most gratifying. They came forward in large numbers, not only from the unemployed, but many women who had never worked before felt impelled to make their utmost contribution, and work was found for them in directions which were hitherto undreamed of.

¶ It may be interesting to recall that at the most critical period of the last war in 1918 more than 1,750,000 women were doing men's work in industry and in transport, quite apart from those who had joined the various women's auxiliary services. The effort we have to make to-day is greater by far than the effort that was needed then, and yet for long and weary months

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neither female nor unskilled labour has been used with the enthusiasm which alone can make it effective. They manage these things—as indeed they manage many other things—better in France, where women are now working in every kind of war industry at wages far lower than here, and for hours far longer than we should dream of asking of them.

I have been in close contact with representatives of the French Government in this country, and I know the profound disappointment felt in France at our slowness to recognise the need for more extensive dilution and a great strengthening of our totally inadequate night shifts.



One does not expect to make women into engineers—yet here and there one comes across a woman having the gift of mechanical instinct. Such instances are rare, but women do possess many valuable qualities which enable them to carry out the simple repetition jobs in an engineering shop in the most satisfactory way. They possess patience and the ability to carry on monotonous tasks without getting disgruntled. In many operations requiring deftness of movement and sensitiveness of touch, they excel the average man.

I can quote two instances that strike me as remarkable. In a works manufacturing electric lamps the inspection of the coiled tungsten filaments, which is a most exacting job, is done most satisfactorily and rapidly by women. It is amazing to see the speed with which they decide whether a filament is or is not correct.

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Another instance is the final inspection of the races for ball bearings, in which it is important to avoid what are known as "shadow marks." The manager of this works confessed that his men were unable to inspect these jobs either with the speed or the certainty that his female inspectors easily achieved.

One does not expect that the average woman will be called upon to set up machines, to rectify breakdowns or to change over a set of tools from one job to another, but on the many repetition opera-



tions in which thousands of pieces exactly alike are produced, she quickly learns to excel.

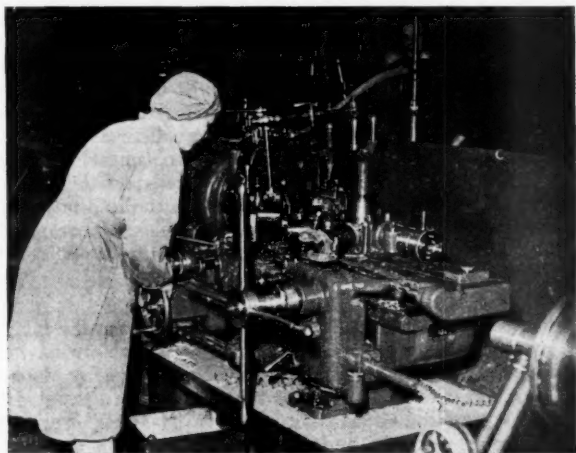
There is a limit, naturally, to her physical capacity, and no woman should be called upon to undertake jobs involving heavy lifting or muscular stress, though in the last war girls of good physique were operating, most satisfactorily, heavy turret lathes producing shells up to 6 in.

Since the last war many women have continued to do the lighter classes of mechanical work, and in shops where they have been so employed there is no opposition to increasing their numbers, but there is distinct and definite opposition at present to the introduction of women into any shops in which it has not hitherto been customary to employ them.

It is obviously necessary that these restrictions should be relaxed during the war.

Now we come to the question of employing women on night shifts. For some time Home Office restrictions forbade the employment of women on night shifts, and it was a long and tedious business to get these restrictions relaxed, but they have been relaxed in many instances, and there is no difficulty now in securing permission from the authorities.

Where women are employed at night it is necessary that there should be a competent female welfare supervisor, and that provision should be made for their comfort and safety. However, it must be borne in mind that to-day there is little, if any difference in the conditions which exist at night from those of day shift work. Most of us have been compelled, as a part of A.R.P. precautions, to blacken our glass roofs and windows and consequently even our



day shifts have to work by artificial light, so that in this respect the conditions are the same. Moreover, night shift workers certainly enjoy a much larger proportion of the day light hours than those whose days are spent at the factory.

The normal time for women on night shifts is forty-seven hours per week, and this gives them ample margins for rest, refreshment, and a good deal of relaxation in the open air by day light. Moreover, from six a.m. on Saturday to eight p.m. on Monday they are free—a week-end that would be envied by many of us—and on

the top of all this they are paid time and one-fifth over the day shift rate.

It is usually desirable that there should be an interchange between day shifts and night shifts so that everybody gets a fortnight on each shift.

In assessing the capacity of women we must get rid of the last remaining Victorian ideas on this subject. For many years back women have had the vote and, as they exceed men in numbers, and as the country is governed by majorities, it is not far short of the truth to say that we are governed by women—not only in our homes, as we all realise—but in the national sense as well.

Every profession is open to them and there is scope for them in every industry. We must not absolve employers from blame in their slowness to recognise the necessity of women's work in war time. Many of us find it hard to get rid of the preconceived ideas and prejudices, and all this out-of-date reluctance to get on with the job must be removed.

¶ All hesitation regarding the employment of women or young persons on night shifts is melting away ; it must be swept away.

We must act in advance of legislation and any laws of a restrictive character must, with all other bogeys, be disregarded.

I can tell you on authoritative information that about 60% of French arsenal employees are women. Not only do they do semi-skilled work, but in certain cases they are actually working large and heavy machines—horizontal boring machines, planers, and the like. The instruction to French women in the factories is also reported as being thorough and excellent.

Shortage of Material.

In addition to the shortage of labour with which we have been confronted for many months, there have been growing signs of a shortage in many of our essential materials. We have to make up our minds that the situation in this respect is likely to become continually more difficult, and we are all faced with the need for making such changes in our practice regarding materials as may be forced upon us. It is a bye-word that Germany has achieved remarkable success in what is known as Ersatz material. We have been accustomed to look on this with a certain amount of amused complacency, but we must realise that we, too, are at last compelled to follow her lead.

It is deplorable that an engineer should be forced to use any material other than that which experience and practice has proved to be most valuable, but if we cannot get cake it is better to eat bread or potatoes rather than to starve. There is a shortage of aluminium. My company has already reduced its use of aluminium to a fraction of its normal practice. There are definite indications

of shortages in certain classes of steel. It is clear that whoever goes short of steel of the highest grade, neither the Air Ministry nor the War Office must be asked to be content with anything short of the best. On the other hand, many of us can adopt substitutes with admittedly some loss of quality or of durability, but again I remind you we are at war.

Steel forgings may be replaced in many instances by malleable where human life does not depend on the change. Certain classes of the cheaper bronzes may also be used. Frequently a steel of a particular analysis, which may prove difficult to obtain, may be replaced by a steel of different analysis which happens at the moment to be more plentiful. Certain classes of steel can be bought from America and while licences are necessary to import, these Licences are obtainable if a proper case is made out. It is clearly to our advantage to import steel rather than the finished product because the importation of the raw material puts much less strain on our dollar exchange than the importation of the finished goods, and while we can always find ways and means of making internal payments, the making of external payments becomes more and more difficult.

In the last war Germany actually went so far as to use concrete in place of cast iron in some of its heavier engineering products and I believe Dr. Schlesinger has had experience in this direction and in many other problems of substitution. I think he can render no greater service than to publish among the members of our Institution all information that is available in this direction.

Ball bearings are difficult to obtain and the shortage will become more acute. I think it is our duty to dispense with the use of ball bearings wherever this is possible. I agree that for certain purposes we must still retain anti-friction bearings, but on the other hand there are many instances in which they can be replaced by plain bearings with but slight sacrifice in efficiency.

The problem of paper, owing to the interruption of supplies, is also becoming acute. We have been accustomed to waste paper luxuriously for the last twenty years. Economies in this direction are now forced on us. Much paper is habitually thrown into waste paper baskets which is capable of being used. Letters can quite well be written on both sides rather than on one. In many cases a letter which normally occupies half of a full sheet can be written on both sides of a half sheet. The length of correspondence can, with a little thought, be greatly reduced to the advantage of both writer and reader. Postcards can be used instead of letters. Simple printed forms can frequently be substituted for lengthy correspondence. Many other ways of saving paper will occur to anyone who takes the trouble to think. With proper economy the country can manage perfectly well with half the paper used in pre-war

time and the amount of shipping and timber that would thereby be released for other and more important purposes is very great.

Priority

¶ And now I would say something about priority. Government Departments are supposed to guide us in regard to the relative urgency of innumerable requirements, but it is difficult—as it always has been difficult—to get clear instructions in this respect. Generally we are told that *everything* is urgent. This gets us nowhere. If first things are to be put first, then second things must come second. Thus some order of procedure is established and confusion is reduced. Even in this difficult matter of priority we must use our own judgment and intelligence, and that will carry us a long way. In every shop there is always some work which we know comes second to the most urgent. Labour and machines should be concentrated, so far as possible, on the work which we know to be of the greatest and most urgent importance and this, of course, means some delay to the least important work.

Long-term programmes must to-day give place to short-term requirements. Munitions—using the term in its widest sense—which can be finished and delivered to-day are more important than others which can only be completed next week, next month, or next year. If a machine can be brought into operation to-morrow by robbing the equipment of other machines which cannot be used until later, then do not hesitate to rob.

A long-term programme bears the same relation to a short-term programme as strategy bears to tactics. When troops are actually in conflict and fighting for their lives, nobody thinks about the strategy—good or bad—which has brought them into that situation. The only thing that counts is to fight it out and finish the job. In an industrial campaign, such as we are fighting, the long-term programme provides for future increases by the establishment and equipping of the new factories required and by finding the necessary labour and material to get them going, so that their output may, in due time, add to that overwhelming mass which we need. However, we may find ourselves, as indeed we do, confronted with the risk of losing the war before our long-term plans have begun to give us any results. In these unfortunate circumstances, we are obviously driven to work to a short-term programme, so that we may stave off the enemy from day to day and get breathing space. It is clear to the man in the street that the main things we need this week and next week, this month and next month, are airplanes, anti-aircraft guns, anti-tank guns, bombs, and ammunition. Even at the cost of delaying the completion of some of our long-term schemes we

must divert to more immediate purposes some of the machinery destined for them, but now standing idle.

Every manufacturer who is capable of undertaking war work should sacrifice his ordinary peace-time trade and devote his whole energy to the war effort.

Although export business is of great importance, yet the war effort must now be placed first.

On this subject of priority action must be taken *now* and skilled labour must be found for those firms engaged on aero-engines and airframes, particularly for fighter aircraft. Skilled men employed on peace-time work—and there are still many—and in this I include export work, must be taken from their jobs without delay and drafted to airplane manufacture. This should be done locally wherever possible, as in this way disturbance of homes and waste of time are avoided. Firms employing skilled men on non-essential work must give them up quickly. Do not wait for the Government order, which will come in due course, but act now. Let those who need labour for aero-engine work ask all their neighbours who have such labour engaged on non-essential work, to surrender it, and let those who have such labour come forward and offer it to those who need it for aircraft work. The men will move without hesitation. The time is approaching, if it is not already here, when men must be taken even from war industry, when they are engaged on jobs which cannot be productive in the near future. I visualise that machine tool makers may quite likely be called upon to allow some of their skilled workers to transfer to airplane and aero-engine work. I have already agreed to make some sacrifices of this kind myself. Needless to say, men must not be taken who are engaged on the completion of machine tools that can be finished within three or four months, but machine tools that are not due for completion until a much later date may well have to be put in the second, instead of in the first, category of urgency.

I do not want to find, on my return to Coventry, that everybody is asking me for men; there must be reason and fairness. There are large numbers of machine-tool makers and if they each contribute a few, the situation will be helped without paralysing output.

If you have the ability and the plant to do war work and find difficulty in getting orders from the Government—as is quite likely—then I suggest that you go to your neighbours who are overwhelmed with orders and behind with their deliveries and offer to help them by sub-contracting.

Now for a few minutes I will speak as a machine-tool maker. In ordinary times machine-tool makers and importers spend their whole lives and energies in trying to help you, their customers,

but in these extraordinary times it is desirable to ask you to help machine tool makers to the full extent of your ability and I make the following suggestions to this end :—

(1) Even if you are engaged on war work do not order new machine tools so long as you have similar machines standing idle at night.

(2) When you are compelled to order a new machine tool and where there is a choice between two types, always order the simpler machine instead of the more elaborate, provided, of course, that either type will accomplish the work you have to do. By this means you will enable machine-tool makers to increase their output of productive units.

(3) Small tools, particularly for capstan and turret lathes and automatics, present the gravest problem, and all machine-tool makers are snowed under with orders far in excess of their output. I suggest very strongly, therefore, that you order only those tools which are actually essential for keeping your machines continuously at work. For instance, when you order dies, ask only for those particular sizes and types which are wanted for immediate use, and do not order other sizes on the chance that they may be useful some day. Do not buy complete sets of chuck collets and similar items but buy only those sizes which you need for your current work. Do not look on one capstan lathe as a unit for which it is necessary to order a full and complete equipment but consider the group of capstan lathes as the unit and order only sufficient tools to keep the group at work.

(4) Keep your spare tools in the tool-room so that they may be at once available for any machine, and do not let them accumulate in the shops when not in use.

(5) Look very carefully through all your accumulations of small tools which are not in use or likely to be in use immediately, and offer such tools to the makers. They will probably be glad to buy them back from you in order to help other companies.

When sending orders for small tools comprising many items I suggest that you arrange these items in the order of priority in which you need them. It is useless to say that they are all wanted at once. If you will establish your own order of priority, you will find that your suppliers will do their best to give effect to it.

(6) While in ordinary times it is the pleasure and duty of machine-tool makers to give the fullest help from their service engineers, remember that in these times the demand for the services of these engineers is far in excess of what, as human beings, they can accomplish. Therefore, to the ex-

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tent that it is possible, help yourselves, and relieve the machine-tool maker who is driven frantic by calls for service on the masses of new machines that are being put into operation.

(a) Do not ask for demonstrators before making sure that the machines are ready to run and complete with all necessary equipment.

(b) In some cases demonstrators are kept waiting for long periods in offices instead of being taken at once into the shops. This should be avoided.

(c) Give demonstrators convenient facilities for grinding tools and making adjustments, and be sure that when the demonstrators arrive your operators are already on the spot and available.

(d) Wherever it is possible for small repairs to be done in your own shops, machine tool makers will be thankful if you will help yourselves rather than call on them for fitters, except in cases of real necessity.

Although it may sound incredible, and although I cannot trace that it has happened to my company, yet I have been told that in some cases attempts have been made to induce demonstrators to leave their jobs and to take up work with the customers of those who employ them.

Conclusion.

The three-shift system of eight hours per shift is the ideal, because by its use it is possible to keep machines running during the full twenty-four hours, but as we have not yet succeeded in bringing enough labour into the industry to run two shifts, it is hopeless to attempt the three-shift system, save in exceptional cases, until the labour position has been realised and full use made of female labour.

As a result of my activities in advocating dilution by bringing all unemployed into the industry and by the introduction of women to the fullest possible extent, I have already been subject to a good deal of criticism. I have been charged with having personal axes to grind, and with the desire to introduce unskilled labour merely because it is cheaper. These suggestions leave me cold. They are untrue and those who have made the charges against me know they are untrue, and I am just as anxious that the measures I have suggested for increasing output should be taken by other companies as my own.

When I think of the important influence which is exercised by so many of those who have been kind enough to listen to me to-day, I am convinced that a great step forward could be made if each would determine to throw his full weight into the struggle and in spite of difficulties and discouragements to get a much larger pro-

portion of our machinery at work during the night instead of letting it lie idle.

Our allies have left us far behind in the way that they have tackled the problem, but they have been invaded twice within living memory, and they know what it means. Do not forget that invasion of this country must definitely be reckoned with, unless the necessary munitions for offence and defence are provided in the required quantities and in the shortest possible time.

"He who is not with us is against us." We can rely on the immense majority of our citizens for the fullest and most loyal co-operation, but there is a minority who are not fully with us, and some who are definitely against us. Papers are still published whose aim is definitely to obstruct and to delay. If the opportunity arose I fear our enemies would have no difficulty in finding "Quislings" here even as they have done elsewhere.

Gentlemen: We are at war.

Discussion

MR. L. AUSTIN (Section President, in the chair). It is a tribute to our speaker to-night that we have here such a large number of engineers, representing as they do the most important engineering firms of this and the surrounding districts. We have had great difficulties to contend with in connection with to-night's meeting. First, there was the short notice, then the black-out, overtime, and to make matters worse, one of His Majesty's Ministers, Sir Walter Elliott, is in Leicester to-night, speaking on "The course of the war." We have Sir Alfred telling us that we are at war and then a quarter of an hour later Leicester is hearing from Sir Walter about "The course of the war."

On the subject of to-night's paper, Sir Alfred has very decided views, and I may say that in this connection he had not hidden his light under a bushel. His letters to the press have been characterised by vigour and clarity. He was asked to give us a paper—he has given us a *challenge*, "We are at war." The question of labour, is outside the purview of the production engineers as a scientific institution. The views on controversial subjects expressed in his paper must therefore be regarded as the views of Sir Alfred Herbert, and not necessarily those of the Institution of Production Engineers. But the introduction of unskilled and semi-skilled labour means the revision of planning, and this alteration of production methods to suit the change of labour is essentially a production engineer's job. This matter is of such vital importance that it is our national duty to do what we can.

In the course of his paper, Sir Alfred referred to himself as an old man. I should imagine that he is the only person in this audience who would dare to do that. If ever I have the pleasure of again presiding at a meeting at which his is going to wrestle with a problem such as this, I shall not trouble to announce him in the customary manner. I shall just say, "Seconds out of the ring!"

He has given us the benefit of his experience in the last war. Now, I sometimes think that we are inclined not to take full advantage of this. Some of us, however, may recall what happened at that time. We had women doing all kinds of heavy work—we even had them machining 9.2 shells, which I should imagine weighed somewhere in the region of 400 lb. They handled them with complete efficiency, and in some respects they beat men. The problem was tackled in 1916, and it can be tackled to-day. The experience then gained tells us that women *can* do the work, and that they can handle monotonous jobs even better than men.

MR. GILL : Regarding the point that was raised by Sir Alfred in respect to labour, would it not be possible to get the goodwill of the Trade Unions and the skilled men during the period of prosperity by encouraging some joint methods of making provision against the period of depression which may come after the war. This could be done by building up some reserves which might be tapped during that depression period for the benefit of the skilled workers, who now feel that they are making sacrifices ? If something of that character were done, it would go a long way towards getting them whole-heartedly on the side of winning the war.

Another point is that firms such as Sir Alfred's (as a result of research) are favourably placed for using " ways and means " which are far in advance of anything others are now " attempting to do." Is it not possible for invitations to be broadcast for men to be sent into research centres in order to study the advanced methods used by the more progressive firms, so that these methods may be put into practice in their own shops ?

SIR ALFRED HERBERT : May I answer these questions as they were asked ? I rather gather that your first question had reference to some kind of deferred pay. The subject has been mooted by the Government, as to whether it would be possible to get workmen to agree to contribute to some fund during the war. This would achieve two objects : (1) Provide some money for the immediate use of the Government, and (2) be available after the war for repayment to the worker in time of depression. I do not think, however, that this is a thing that could be done by individual companies very well. It would have to be a national thing.

With reference to going over the larger works, there are very considerable facilities available to all who are interested. Frequently members of the Institution of Production Engineers have opportunities of visiting works in their own and other cities. And, with all due modesty, if there is anything interesting in Coventry at my place, I shall be very happy at any time to receive members of this Leicester branch, and to show them what little I have to show.

MR. T. SYKES : I am rather disappointed that I should have to come from Coventry in order to hear a Coventry gentleman deliver this lecture. I should like to recommend to our General Secretary, Mr. Hazleton, that the Secretary of the Coventry branch be asked whether Sir Alfred would give this lecture in Coventry.

In Coventry there is a shortage of labour just the same as anywhere else. Will you tell me why ? And what action you would take in a case where it is possible for a man to come into your factory on Monday morning and go out again on Wednesday, just because he finds he can go into another factory at a penny an hour more ?

I was very interested in the slide illustrating the 100% of machines

in use during the day and only 50% at nights. What action would you take when men definitely refuse to work night shift, and when the Trade Unions have no jurisdiction? Why do we not do it ourselves? May I make a suggestion to you—that the Employers' Federation in Coventry should get together, and say, "This has got to stop" and implore the Government to do something at once. We should like to fill our shop, but cannot get the men to work at night. We dare not discharge them. Youths, especially from nineteen to twenty-three years of age, will not work nights at any price.

SIR ALFRED HERBERT: I imagine that in a country under a dictator, such a point could not, and would not arise. But we must remember that one of the things for which we are fighting is the freedom of the individual, and any suggestions to coerce labour would be entirely contrary to the principles of democracy. All that we can do (as I have tried to do tonight) is to bring out into the daylight certain of our difficulties in the hope that labour as well as employers will appreciate the seriousness of the position and give us their help. We cannot make the men work at night, but we can often persuade them to do so. We ourselves have succeeded in getting 824 people to work at night. It is small—only 55% (that is, 55% of machines, not of the total labour). Going on quietly, we have 260 women working in the daytime, and we have 53 women working at night. You will all appreciate, and I do not mind telling you, that it has been a hell of a job, but gradually the position is getting better.

MR. SYKES: It seems to me, Sir Alfred, that in Germany they are suffering from too much "Hitler" while we in England have not sufficient.

SIR ALFRED HERBERT: It is a mercy then, that you cannot do as Solomon did with the disputed baby—cut him in two and have a bit each!

MR. R. HAZLETON: Sir Alfred told us at the beginning of his address, that as a result of the hospitality which he experienced to-night, there might be some possibility of his falling asleep. Well, he did not do that—neither did we! This reminds me of a little story which the late Duke of Devonshire used to tell against himself. "I dreamt," he said, "that I was making a speech—and when I woke, I found, by Jove, that I *was*."

As General Secretary of this Institution, I have only risen for one purpose, and that is, to remove any misapprehension that may exist in Sir Alfred's mind to the effect that your Section President, Mr. Austin, was making any excuse for this meeting or this lecture tonight. At the beginning of the war, Sir Alfred, as a member of our Council, communicated with the Council regarding the necessity for urging the ideas he has put before us to-night. While it was perfectly clear that the Institution as a scientific body could not

intervene in matters pertaining to the Employers' Federation and labour, the Council did assure Sir Alfred that he had their whole hearted sympathy in the efforts that he was making on these lines, and I hope that Sir Alfred will feel that in giving him this platform to-night, the Institution is doing what it can to further these ideas. I can assure Mr. Sykes that while it may not be possible to get Sir Alfred to many other meetings such as this, to-night's address will be published in full in the Institution's journal. I would like to conclude by expressing our own appreciation and thanks to Sir Alfred for coming along and helping us in this matter to-night.

SIR ALFRED HERBERT : I appreciate very much the kind remarks of your General Secretary, Mr. Hazleton. I should like you to understand that I have no personal axe to grind, but I do have a burning conviction that this subject is of supreme importance, and I should be failing in my duty if I did not do just what I can to help the idea. If even a few more people could concentrate on employment on war material, we should be going a long way towards bringing this war to an early and successful conclusion.

I hope you will forgive me if I seemed to be lecturing you. I should very much have preferred to have come in times of peace, with a light heart ; but in the present circumstances we can only hope that those times—as a result of our united efforts—will soon be with us again.

I also appreciate very much the compliment which you have paid me in coming to hear me to-night ; I feel that as a result of the black-out, and to-night's counter-attractions in Leicester, this hall might easily have been empty. May I also thank you for the lavish hospitality which you have extended to an old fellow-townsmen.

MR. J. HOOD : Having travelled from Coventry to support Sir Alfred, I feel that I would like to support the General Secretary's remarks, and, at the same time show appreciation of the publicity being given by Sir Alfred to this subject, because I believe that the Institution in dealing with the practical and technical problems involved in war production, can help us. It has been very interesting to listen to the lecturer's point of view, and to have the opportunity of discussing how the problem affects us as production engineers.

Sir Alfred says he has no axe to grind, but the affection for our country, the lives of our fellowmen—in some instances our relatives—and the fight for everything that we believe to be fair as free-thinking British engineers is surely the axe we all have to grind. We are not seeking dilution with all its difficult problems by choice, but are faced with a situation that needs quick and drastic measures. For instance, we are up against the fact that fully qualified setters are difficult to get and to keep, and are needed more than ever to

take care of output, to nurse the semi-skilled and unskilled operators into producing at a much higher rate, and at the same time to avoid that nightmare of all production engineers—"scrap."

We have to get production and still more production with a labour market fluctuating at the whim of the operator, who leaves at the least excuse. I feel very keenly on this subject, for the tool setter of today has a terrific problem in front of him, with the introduction of female labour and the training of dilutees, and he will need all the encouragement and help that the management can give him.

Sir Alfred has pointed out how he thinks this problem can be tackled successfully. This in itself must have been worth the visit of many of our engineers this evening, and I feel sure that events coming quickly will prove him right. The subject has been played with far too long, with no material action or lead being given by the responsible Government Departments.

There is one point, however, which Sir Alfred did not touch upon; will he give his audience the benefit of his knowledge of the procedure in registering supplementary labour? I understand there is an agreement at present operating, where a firm, if it so desires, can start dilution by introducing a semi-skilled man on to a more skilled operation. Application has to be made to the Trade Unions, to have the man registered as an alternate or supplementary labour. The idea of this scheme is to protect the skilled man in his occupation. After hostilities have ceased he claims the diluted skilled operation back again. The Trade Unions having allowed this form of dilution, will be able by use of the register to keep track of the trades in which they have allowed dilution.

I know it is rather a difficult subject to get over, and full of tedious red tape, but this explanation may help some of the executives of the engineering industry in Leicester, if they so desire, to make a start in putting this question of dilution on to a proper footing. In conclusion I would like to say that no doubt all these problems will have to be met on their merits, and the real answer to Sir Alfred's subject is to get on with the job quickly before it is too late.

SIR ALFRED HERBERT: I am fully alive to all your difficulties. My management (sometimes I feel sorry for them) have had all this to deal with. I think I may tell you this, however. In one week we engaged 45 new men, and lost 45. When you touch upon the technique of dilution, you touch upon a difficult subject. I cannot possibly deal with it all, both from the standpoint of labour and employers. The agreement is well known. Many of you are members of the Employers' Federation and the agreements and their interpretations are available through the local Secretary. All the machinery for dilution and registration is set forth. They are very complex and difficult, and cause great delay. That is one of the troubles.

It is possible to enter into protracted discussions which may only end in failure. Meanwhile, the time is slipping under our hands and the war is going on. So far as the technique is concerned, it is there at your hand. In Coventry at first the difficulties were very great, but things are now somewhat better. They have come to realise that it is not logical that their sons and brothers should be giving their lives, and that they should obstruct the production of munitions. All the regulations exist, and you can see them. I cannot profess to remember them all. If you want any information when you get back to Coventry, come to the works and see Mr. Lloyd. Mention this discussion, and he will tell you everything you want to know.

MR. J. H. BINGHAM : It was not my intention to make any contribution to this discussion, but I cannot resist the temptation to join in the tribute paid to Sir Alfred for his most impressive address. It is an address from which I, personally, have received inspiration. Sir Alfred has stated the problem, and pointed the way to its solution. Why cannot that solution be applied ?

Let us contrast the last war with the present one. During the last war, the expansion of the industrial machinery was gradual. And, as the war was prosecuted, and the industrial machinery was expanded and developed, there was realised the need for an increased labour army. Dilution and substitution were introduced. What is the position at the outset of this war ? There is an immediate and rapid change-over to armaments production. Not only is there a rapid change-over but a rapid expansion of the industrial machinery. But there is not the labour factor to equalise it. And why ? I think the answer is to be found in the fact that there is not yet a general realisation that " We are at war."

A vote of thanks to Sir Alfred for his address was adopted with acclamation.

MR. AUSTIN : I conclude this meeting by expressing the thanks of the Leicester section of the Institution of Production Engineers to Mr. Kershaw and his staff for the arrangements to-night.

IMPRESSIONS OF AMERICAN PRACTICE

Paper presented to the Institution, London Section, by

G. W. Clarke, M.I.P.E.

This paper describes with considerable detail some of the methods adopted in U.S.A. for the mass production of small electrical and other products. The extensive mechanisation and thorough co-ordination of all production elements is emphasised. The close co-operation between machine tool maker and user is particularly stressed. Replacement of individual piece work by group systems is mentioned. Safety devices are criticised.

In addition, in the discussion which follows the paper, the relative well being of the British workman and his American counterpart is debated.

IN the spring of last year, my company delegated two of its engineers to pay a visit to the United States and to spend two months in a general tour through various manufacturing plants. The object in view was that of observing conditions, methods, equipment, and organisation, and to utilise the experience so gained in the general improvement of our own practices.

Your committee felt that a brief account of the impressions gathered in the course of such a trip might be of some interest to members of the Institution and might even afford a little relief from some of our war-time worries.

You will understand that I claim no intimate knowledge of American practice, and can only comment on what was actually seen and heard, but you will also appreciate that an opportunity of seeing the job under different conditions and from a new viewpoint is bound to start up fresh lines of thought in many directions.

In the course of this trip, twenty different plants were visited covering a wide range of products, but as our interests lie chiefly with light electrical manufactures, the plants chosen were either of similar type or such as would offer direct comparison in some way or other.

Before proceeding to give specific details, it may perhaps be advisable to mention certain general features which were noticed.

(1) The Americans seem to devote more care and effort in planning a job through all its stages than we generally do. Labour and skill are regarded as commodities of great value and great care is taken to avoid wasteful use of either. Every effort is made to make the machine do the work, whatever it may be, and to avoid handling and manual work between stages.

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One can almost feel the existence of an unwritten commandment, "Thou shalt not pick up a job twice when once can be made to suffice," and this is their justification for much expenditure on machines, tools, and equipment.

(2) Another impressive feature is the manner in which improved production methods and technique are followed up in the product design. Such improvements are exploited to the full by changing designs so as to extract the maximum advantage from the new methods and a few remarkable examples will be mentioned later.

In this connection, it is interesting to note the great importance attached to close intercourse between the manufacturing shops and their associated engineering offices. The view is strongly held that those responsible for design must be kept fully aware of the possibilities of improved production methods and American works are prepared to go to the very great lengths in securing close co-ordination.

(3) The machine tool makers and manufacturing firms seem to work together far more closely than is common in England. The manufacturer seems to send his technical problems to the machine tool maker who takes the onus of producing and offering a solution. The tendency is to call for tenders for equipment to carry out a given job and to judge offers by the guaranteed cost of the work to be produced rather than by the price of the machines offered. In other cases the machine builder who is producing a new model will place it into a factory at his own cost for trial under the most severe conditions, overcome difficulties which may arise and effect improvements until both parties are fully satisfied that the machine is fit to hold its own in a highly competitive market. Development work of this nature frequently results in valuable patents which offset the expense incurred.

(4) The attitude towards piecework differs considerably from that adopted here. Where complete mechanisation exists, the timing is controlled by the mechanism and piecework has disappeared. Where partial mechanisation is employed, individual piecework has been largely replaced by group systems and in some cases by systems of ability rates on the grounds that the overall cost of stoppages for counting and inspection together with the clerical work exceeds the value of the results obtained. This attitude seems to be part of a general effort to reduce complex works systems to simple forms and to effect some diminution of the clerical work incidental to running a factory.

(5) In the course of the trip, particular notice was taken of safety devices and safety measures. Means for dealing with accidents after they have happened by way of first aid stations, dressing rooms, etc., were generally very good, but guards and

means of preventing accidents fell far short of the standard required in Great Britain.

The plants visited varied widely both in size and character and it was noticeable that the most advanced manufacturing methods and technique were to be found either in the smaller factory or in the very large ones. The smaller works tend to specialise on a single product and to concentrate their whole energy on its efficient production. Similarly, the large mass production works are divided into sections, each section handling one particular product or part of the product, and in some instances the sub-division is carried so far as to include the creation of a ring of satellite factories surrounding a large central plant. It is held that problems of production and management are considerably simplified by these means and that a high state of efficiency may be maintained.

I will endeavour at this point to give you a brief account of a fairly large factory producing very high class products in a wide range of small lots. Its output comprises tabulating and calculating machines, accounting machines, and a great variety of office machinery which by reason of its intricate and varied nature, presents a complex manufacturing problem. This company does not sell its machines but hires them out to customers and provides all the skilled service and mechanical help required. The training of such help forms a large proportion of the company's effort.

The main buildings comprise a series of four storey blocks, the space between blocks being covered in so as to provide a continuous ground floor of very large area. Each block is provided with lifts at both ends and a very complete ventilation or air conditioning system operates throughout the plant. Receiving department, shipping department, stores, and the machine shops are all located on the ground floor. Railway and road facilities are well planned and placed.

The organisation is divided into two main channels—engineering covering sales, design, and customers service, and manufacturing embracing all phases of production. A factory superintendent and a chief engineer each responsible to the Vice-President head these main branches. A section of the engineering force is attached to the factory organisation and functions as a co-ordinating unit between engineering and manufacturing. Accounting, billing, and pay roll are dealt with by a comptroller. Rate fixing does not exist. Inspection is dealt with under a chief inspector who is held responsible for quality and correct functioning of product throughout the works.

Transport is handled throughout by electric and petrol-driven trucks designed to lift, carry, or stack platforms. Conveyors are not used except in the paint shop.

The machine shops are divided up in conventional fashion into auto and turret, drilling, milling, press, heat treatment, plating, painting, and model shop, each having a foreman and assistant together with inspectors and progress men. The shops and offices work the same hours eight a.m. to four p.m. and the whole plant is shut down on Saturdays.

Time will not permit me to mention many details respecting these shops, but in general they were exceedingly well equipped and laid out. Most of the machines have self-contained motor drives and the proportion of new machines is very high. An outstanding feature is the extensive provision of special tools and fixtures and the organisation employed for their issue, storage and maintenance. The greatest care is taken to ensure that tools cannot return to store without thorough inspection and repair. It is considered that the use of special tools is justified not only by direct reduction in operating times but also through the saving in setting time and the consequent increased machine activity. For example, one sees in this shop and in most of the shops visited that press tools, even if only of simple form are invariably fitted with pillared die sets often of an expensive type. The setting reason is usually put forward as their justification.

The model shop located centrally to the main shops was a point of some interest. Equipped with a full range of machine tools and a skilled staff, it deals with development of new models. It also functions as a jobbing shop, handling small quantity work and jobs of special difficulty and even salvaging defectives turned aside by the inspection department.

Men are employed throughout these machine shops even on simple drill press operations such as burring. The general speed of operations seems to be definitely slower than that in corresponding British shops although one gathered an impression of steadiness and care on the part of the operators who, in conversation showed considerable interest and knowledge of these jobs. There are no setters; each man is expected to set his machine, operate it, and produce satisfactory work.

The assembly shops located on the upper floors are laid out to assemble machines in a logical sequence of sub-assemblies, unit assemblies, and final machine assembly. A series of feeding stores supplied from a main component store are located at suitable stages and act as pre-selection and checking points on the work flow.

A separate partial assembly shop handles all minor assemblies comprising only a few parts each. Perhaps an example of the sort of work it does will best illustrate its function.

The machines built embody a very large number of electric relays and connections are made by cord tip and binding screw instead of the usual soldering method. The spacer blanks are pro-

duced and plated in the machine departments and sent to the partial assembly shop where they are fed into a special machine. This is fitted with a dial feeding device and not only drills, burrs, and taps the screw hole, but also inserts the screw and spins over the end to prevent withdrawal, the whole operation being automatic.

Many of the unit assemblies produced are of a very complicated nature and include a multiplicity of cams, levers, etc., which must be set in very accurate relation to each other and pinned in position. It was significant that a great number of ingenious locating and holding fixtures were in use, many of them incorporating dial gauges in their make up, these permitting the operator to see exactly what he is doing, thereby making an exacting job comparatively easy. This practice of including indicating gauges in assembly tools was noted in several other shops during this trip, and seems to be of general application.

Another noticeable feature in these shops was the extensive use of compressed air for operating jigs and fixtures. Power screw-drivers were driven by the same means. Here is a typical illustration. The cord tips are attached to the connecting wires by clinching the wings of the top around the insulation while the wire is actually welded to the metal of the tip. This operation is carried out in a small welding machine, the fixtures used incorporating a clinching device operated by air so that operation of the machine pedal brings down the electrode, holds the wire in position, switches on the welding current, trips the air clinching device and returns the machine to starting position, the whole operation occupying about one second. A large and well equipped tool room is located in one block and this is laid out with machine and bench sections in the usual way, machines being grouped by types. This shop has a large battery of Swiss jig boring machines, and is well supplied with gauging and measuring equipment of all kinds. Fully detailed drawings are supplied by a tool design department, located close to the tool room.

Process planning is included in tool design and produces operation sheets for each part made. These are reproduced by blue-printing and circulate with the work as job cards.

The safety measures operating in this factory were the best seen. A safety committee functions under the chairmanship of the superintendent and a safety officer is notified of all accidents when he is expected and authorised to take immediate preventive action. Lighting, heating, and ventilation are supervised by the committee in addition to the ordinary safety matters.

The activities of the personal section were of interest and on a scale far beyond anything attempted in British plants. It includes country clubs, golf courses, swimming pools, libraries, and many other features. The land surrounding the club houses amounts to

about 1,200 acres, and includes some beautiful stretches of mountain and forest scenery. One large piece of land is being built over with houses for employees. The building work is done by the company and a loan scheme similar to our building society plan operates to cover the purchases.

Apprentices, who must have the equivalent of a high school education, are accepted at eighteen years of age, the course extending 8,000 hours or four years. Evening classes in many subjects are run within the works from September to May, the total attendance exceeding 1,000. A day school for training service men and machine operators is regularly at work and its staff and facilities are used for the evening classes.

Finally, a large building fully equipped with laboratories, machines, etc., is set aside for research and development both in product and manufacturing methods.

In contrast to this may we, for a few moments, consider one of the huge mass production factories of which the Ford works at Detroit is an outstanding example. The main factories are of vast proportions and although business was dull at the time of our visit, they employed 70,000 people. It is only possible to get a general view by touring round in a car, and most of the shops have car roadways running through them. The plant, situated close to the lake, has its own docks, and a fleet of ships bringing coal and ore and materials and taking away finished products.

Commencing with blast furnace and coke oven installations located close to the docks, a large area is devoted to foundries, open hearth steel furnaces, rolling mills, etc., all being mechanised to the last degree. By-product recovery plant of many kinds is in operation and the last addition is an outfit for producing cement from furnace slag. The works also produces its own supplies of plate glass and all its enamel used for finishing.

A plant so vast and containing so much could not be adequately described in the compass of a discussion such as this, and I will not attempt to do it. Many of its outstanding features are already well known. We did, however, make a second visit to inspect the press shop, tool room, and finishing shops, and a few notes of the outstanding items may be interesting.

The press shop is in a building about 2,500 ft. long by 350 ft. wide, and most of the production lines are laid out to progress across the shop. Each main component of the car body has its own production line including the assembly of such parts as may be secured by riveting, welding, or soldering.

The lines are set out so as to provide a machine or machines set up for every operation involved. Starting with coiled strip in many cases 6 ft. wide, the parts are blanked, roller levelled, and passed through the various press operations. In most cases parts do not

reach the floor but are pushed along slides or carried from machine to machine. Local annealing is done by acetylene torch as the work passes. In most cases the men take out of one machine and feed into the next. Chutes through the floor at suitable points serve to clear away scarp as it is produced. Passing along the line, the parts reach the lighter machines for spot welding, local piercing, etc. Many special welding machines are used varying from multiple hydromatic to portable, the larger ones being served by two men, one locating the work into lower jigs, the second into the upper members. The outfit of welding machines is very extensive and must represent a tremendous amount of experimental and development work.

Parts requiring soldering, such as petrol tanks, are lopped out by conveyor to a special line of equipment, and return to the main lines at the proper points. The various components come together at the far side of the shop at approximately the right position in a body assembly line and are slung into welding jigs, clamped together and spotted up with portable welders and torches.

At a certain stage the partly assembled bodies leave the building by conveyor for the finishing shop. They meet here certain other parts which have been subjected to some form of finishing before assembly and the main body assembly is completed by the addition of these parts.

The main press shop is divided overhead into three long sections each served by 50-ton high speed cranes, and on the floor a wide gangway extends the full length of the building next to one wall.

The first cutting presses are located on the gangway which is wide enough to take heavy locomotives and trailer cars. Material comes in by car and is handled into the machine stands by overhead crane. These also handle piled parts when required and act as highly flexible supplementaries to the permanent conveyor chains.

It is noteworthy that the whole shop does not include a single "C" frame press amongst its equipment. All the larger machines are double sided and many hydraulically operated. The smaller presses are all open-fronted with overhung outboard bearing to crankshaft, and dies are invariably pillared.

Larger presses are provided with electrical trip gear so arranged that, in order to start the machine, all operators must simultaneously press buttons situated at a safe distance from the machine. Very few guards of other types were noticed, and most of the smaller machines were operating full open. Operators throughout the shop are grown men, mostly white.

A system of overhead galleries provides accommodation for service piping and welding controllers.

One corner of the shop is equipped with tool room plant and a large staff of over 500 men is employed to effect running repairs

and maintenance of tools and machines. Major repairs are handled by the main tool room.

The tool department is in the ground floor building 2,500 ft. long by 350 ft. wide. The shop is divided longitudinally into three by two main gangways, each section being served by 50-ton overhead cranes. Galleries are provided for lavatories and meal rooms. The floor space is completely laid out and equipped with a wide range of plant for tool production and for machine maintenance, facilities being provided for repairing the heaviest equipment in the manufacturing shops. The heat treatment installation is particularly good. The furnaces are located behind a screen having openings for the doors. This screen is finished in black with chromium strips and the instruments are mounted on the front, the whole resembling a large switchboard installation. The exhaust is located at the rear so that air is drawn away continuously through the openings, and as the building is supplied with conditioned air, the result is a remarkably cool and clean shop despite the large number of furnaces. These are ranged along either side of the section with a row of quenching tanks in the centre. The tool shop includes a large turret lathe section and also a grinding section laid out on production lines so that tools of similar type are handled in bulk.

A large space is devoted to the production of gauges and gauging fixtures. A great many of the fixtures and tools used incorporate gauging devices in their make-up. This is the type of work chiefly carried on in the tool room department. Such work as simple plug gauges snap gauges, etc., is purchased from outside suppliers.

Detailed drawings are provided for all regular work and a rigid inspection system is maintained, the inspection rooms being maintained at a constant temperature.

Working hours are eight per day, five days per week, meal time is twenty minutes, and there are three shifts at work.

The preliminary finishing coats are sprayed and in some cases dipped and stoved by conveyor oven in the ordinary way. An outstanding development is the introduction of an entirely new form of finishing stoving apparatus. This consists of a tunnel about 50 yds. long built up in skeleton form the conveyor chain being so arranged as to pass the bodies through it and the inside of the tunnel is provided with a large number of heating units placed close together in rows, the clearance between the work and the heating units being about 15 ins. at the nearest point. These heating units consist of a parabolic reflector gold-plated and highly polished on the inner faces. On the focus of each reflector a high wattage lamp is mounted so that when operating the apparatus appears as a circular skeleton tunnel with innumerable lamps showing inside. These reflectors focus both the heat and the infra-red rays on to the work, the temperature rising to about 360° F

Two lengths of 50 yds. each are used for the finishing coats, and the gear is not enclosed in any way, neither is exhaust apparatus provided. It stands open in the shop and radiation seems to be almost absent at a distance of 5 ft. away from it. It acts as an efficient oven directing the heat and light exactly where required and is instantly available without any warming up period, while gas and exhaust trunking are entirely absent.

It would appear that considerable research work has been done in the development of enamels which respond rapidly to this treatment. Copies of the scheme were observed in some of the other plants visited, and the development has obvious possibilities.

You will perhaps by now be a little tired of factory descriptions and I should like to interpose a few illustrations of some points mentioned earlier in this paper. You will remember me saying that the American plants set great store on a very close co-operation between the production and the engineering or designing sides of each works. In one place this was done by creating a special section of the design to act as a connecting link. This section was recruited largely from the production staff and dealt on the one hand with the many changes required by customers, making all necessary arrangements within the works and on the other hand keeping track of all improved methods and production equipment. By daily personal contact with both sides, the section maintains a constant interchange of ideas and information.

In another large works devoted to the manufacture of radio equipment, the designing and production staffs were partly merged together so that tool designers and product designers are working side by side. This company normally produces a great number of different models which are usually required at very short notice, and the close co-operation mentioned has resulted in a partial standardisation of tools and methods whereby changed designs may be put into production with the minimum expenditure of time and money. A large sample room is installed containing specimens of every component made in the works, and a draughtsman requiring a piece can consult these at any time. He can, moreover, be immediately informed of any existing tools or equipment which may be easily adapted to produce his requirement. A fully equipped model shop runs in conjunction with the design section, and is staffed with highly skilled men. The preliminary work done here is carefully recorded by the tool design people so that the tool department may take the maximum advantage of experimental work already done.

In other factories the staff and equipment is divided up into sections, each devoted to one particular line of product, and each section functioning as a complete organisation dealing with design

and with production so that the various aspects of the job are of necessity brought into very close association.

As a result of such methods one would naturally expect production methods to react sharply on design of products, and I can give you one or two examples which were noticed. Some years ago, a system of copper brazing was developed in America whereby parts could be very securely fixed together by brazing with pure copper. In its original form the equipment was both elaborate and costly because the furnace was provided with an atmosphere of hydrogen. The work was suitably assembled on a base plate and copper in the form of powder or wire placed at the joints when the furnace in the form of a bell electrically heated and filled with hydrogen was lowered over it.

Much development work has since been done in connection with bright annealing and the furnaces now used are heated electrically and provided with a reducing atmosphere consisting of partly burned coal gas or natural gas. These furnaces are often provided with an internal conveyor belt made of nickel chrome wire for carrying parts in bulk through the process. It has been found that the copper brazing process may be carried out quite successfully in these furnaces. The work to be copper brazed is assembled together in some suitable manner either by lightly riveting or spot welding to hold the parts in correct alignment and the copper is applied either in the form of wire or in other cases finely divided copper is mixed up with ordinary lacquer and applied with a brush around the joint. The work is usually degreased, but slight strains or traces of rust are ignored, and the work so prepared is placed on the furnace belt and, passing through, emerge completely and effectively brazed.

Here are some illustrations of design adaptations to take advantage of this process in the manufacture of small compressors.

(1) A pressure vessel required to stand up to 200 lb. pressure and formerly built up from machined parts is now produced from a simple flanged steel shell drawn up in the press. Two shells are put together flange to flange with a ring of copper wire seating at the inner junction of the faces and the halves are held in correct location by lightly spot welding in two places. Passing through the brazing furnace on the belt, the melted copper penetrates between the faces entirely covering the surfaces and produces a perfect joint, failures under the pressure test which follows being very rare.

(2) Radiators working under heavy pressures were built up of seamless drawn tube and after assembly with the fins the tubes were expanded hydraulically to hold the fins in place. The design was changed to use a butted tube produced from flat strip in a continuous multiple rolling machine. As the formed tube emerges

from the roll it is cut to length, trimmed, and burred by a separate device on the machine. The fins in the form of flat strips with pierced holes at proper spacings are assembled over these tubes, the fit being tight enough to hold them in position. A length of copper wire is laid along the seam in each tube and the whole assembly passed through the brazing furnace when the melted copper completely fills the joint and sufficient seeps through to firmly secure the fins in position and ensure a joint of high conductivity.

(3) This example represents a further step in the process of development, and is a very good example of the adaptation of press methods to fit in with the possibilities of a new process. In this case the strip forming the radiator fins is passed through a series of progressive dies in a heavy roll feed press so as to raise a boss by gradual stages and pierce out the closed end of the boss. It is the familiar process normally used for producing a flanged cup when the piece would be blanked at the last stage. In this instance the bosses are produced along the whole length of the strip as it passes through the machine and an automatic device cuts the formed strips to predetermined lengths as the press is running. These strips are assembled together by forcing the open end of the raised bosses into the mouth of those in the next strip, sufficient taper being allowed. The joints are brushed over with a mixture of copper powder and lacquer, and the assembly passed through the furnace to result in a radiator capable of withstanding the pressure test of 250 lb. and produced from one simple cheaply-produced part.

Following the great advance which has taken place in welding methods and the introduction of the press brake, there is widespread development in the use of sheet metal construction in many directions, and the tendency has no doubt been influenced by the car and aircraft shops. Time will not permit me to go into further detail but the examples quoted will give an impression of what is being done.

Concerning machine tools, our interests lay chiefly in the direction of presses and heavy and cold forming machines, and the opportunity was taken to visit some of the leading plants engaged in this type of production. Some impressions gathered with the makers of heading and cold forming equipment will possibly be of interest.

It is generally known that considerable development has taken place in recent years in the cold forming process whereby parts are produced to accurate dimensions by pressure methods. For example, the manufacture of screws and bolts by such means has been brought to a pitch of high perfection and the product will stand comparison with the best work produced by the automatic screw machine while its strength is usually the better. We had heard that certain firms in America were running this class of mach-

ine at very high speeds but did not ourselves find it possible to reach anything like such speeds with the machines at our disposal or on the market. We found that entirely new models had been produced and it was explained that none of these are released for the European market until they have had a very thorough trial for two years or more under exacting conditions in American shops. This policy is regularly followed because they will not risk the danger of unforeseen troubles developing with exported tools. This particular machine is so designed as to totally enclose all the moving parts and the lower part of the framework is filled with oil so that the working members are continually flooded. A pump is provided to circulate the oil through the upper moving parts and to cool the tools while the returned oil passes through a separator to remove grit or chips. It was explained that the high speeds are impossible without a highly efficient oil system. A further development of this type of machine undoubtedly has very great possibilities.

It will be remembered that the ordinary header carries a single die and the mechanism is arranged to deliver two or three consecutive blows to the work while held in the die. In the new scheme, the machine is provided with a row of dies up to four in number, the machine being arranged to deliver two blows to each die. A transfer mechanism built into the machine transfers the work from die to die in successive stages and it thus becomes possible to perform as many as eight consecutive operations on the piece automatically and at high speed, and by this means to extend the use of the cold forming process to a wide range of parts which would normally be made on automatic screw machines.

Some of these machines are producing hexagon nuts up to the size of $\frac{3}{8}$ in. Whitworth directly from coiled rods at a speed exceeding 50 per minute and one machine was seen producing bearing collars from alloy steel using material $\frac{1}{2}$ in. in diameter, the machine running at 60 per minute.

A new method for the production of small hexagon nuts was also of some interest. In this scheme, the nuts are pierced and blanked in a scrapless tool in a roll feed punch press. The resulting rough blanks are fed automatically into forging and shearing dies in a special machine. The faces and bevels are squared up and the hexagonal sides sheared to a smooth finish at a speed of 120 a minute. Automatic continuously operating tapping machines have been developed which use a straight shank tap and clears the nuts over the tap by an automatic jump gripping device which obviates stopping the machine. In this particular works, very great care seemed to be exercised in maintaining a high standard of quality and special equipment was installed wherever its use was deemed advisable.

As an example, an interesting method for cleaning away hard sand and removing cores from machine castings was seen in operation. A large revolving platform was enclosed in a high screen, doors being provided for bringing the work into position, and heavy overhead crane for lifting. On either side of the chamber, water jets are arranged for operation from outside the screen and observation portholes with heavy glasses are fitted. The casting is placed on the platform which slowly revolves. The doors are closed and jets of water at 800 lbs. sq. in. pressure are directed on to the sand and work when the sand, cores, etc., are smashed up and cleared away in a very short time. The sand and water flows down through settling tanks which automatically grade sand for further use. The idea may be useful in other directions. In this case its efficiency was remarkable.

Finally, a few words respecting toolmaking practices. I probably cannot do better than give you a brief summary of the methods used in one of the leading electrical factories.

Working on a definite plan for substituting machine for hand labour, the Hawthorne shop have achieved considerable success, and their methods mark a definite advance in tool design and toolmaking technique. As an indication of the trend, it may be mentioned that in the shops devoted to new tools, the filing machines have disappeared, and the process of filing dies by hand is to quote their own words "Becoming a lost art."

Commencing at the tool designing end, the designers are called upon to so design their tools as to permit every part being made entirely by machine methods. Blanking dies are no longer made solid but are invariably built in sections. These sections are detailed out on the drawing board and are machined, hardened, and ground to finish dimensions, including the various profiles concerned. A die may consist of a larger number of pieces. These are all ground to exact dimensions, keyed where necessary, and assembled together on an accurate surface plate. When accurately set together, metal strips are soldered across the faces to hold them together and the outside faces are then ground to fit exactly into a machine steel ring or jacket already prepared. These jackets are cut out by a profile torch in halves accurately ground inside and welded together with welded cross pins and end welds. Plain rings are used in some cases, for example, the compound die for the toothed impulse wheel is made in halves and set into a ring. The inner profile is ground complete. Lower punch and shedder are made and ground in one piece, the flanges being gashed through to permit form grinding. After grinding to correct form all over, they are cut in half at the correct point with an elastic wheel, and under such conditions absolute matching accuracy is secured. Where larger dies are concerned, the jacket is omitted and the parts properly keyed together

are dowelled and screwed direct to the rectangular bolster plate. Hawthorne have tried the scheme of welding the actual die sections together and found that it causes severe distortion and, is therefore, impracticable. They prefer fitting cross bolts in holes drilled through the die body and weld these over at both ends, the resulting shrinkage ensuring a very tight job free from distortion.

In general, it may be stated that the actual size of the dies is considerably larger for several main reasons.

First, the tendency is to use larger presses because it is found that the added stiffness and general alignment add greatly to the die life.

Secondly, it is now general policy to pierce all holes at the first handling in the press. By so doing, expensive drilling work is avoided as well as its accompanying burring, time and labour being thereby saved at a great rate. It is found that light tools do not stand up to their work when small holes are included. The utmost rigidity and stiffness are required, and for this reason the tools are very heavily pillared. Hawthorne have investigated the question of piercing small holes very thoroughly, and now do it as regular practice.

Thirdly, wherever possible, press tools are now made to produce the part as near complete as possible without subsequent press or drilling operations. This, of necessity, involves an increase in the size of the tools, and the matter of die life takes on even greater importance. It may not be possible to do this all in one tool, and several tools may therefore be mounted on the press together, and various means employed to move the work from one to another. This requires large faces on ram and bolster plate and dictates the larger press. The foregoing reasons are conclusive when considered together.

At present Hawthorne are doing all the profile grinding on standard Brown and Sharpe machines, and it could undoubtedly be very much cheapened and expedited by the new German type profile grinding machine recently introduced into European shops.

It has hitherto been considered inadvisable to incorporate forming operations in cutting dies because of the difficulties brought about through wear and grinding. The built up construction very largely avoids this difficulty and, in addition, every effort is made to avoid sharp bends and corners in the design of piece parts. By close co-operation between design engineers and tool designers, this point has been given due weight.

Many devices are used to secure the additional operations at the first handling. In some cases, ordinary progressive means with station pilots are used. In others, the parts pass from one die to another before they are separated from the stock. In several cases, cross transfer mechanisms are used, most of them operated by air cylin-

ders. A suitable pusher on the top tool operates the valve causing the transfer gear to push the piece across to the next die.

The details of such schemes are purely secondary. Once the principle is accepted and worked upon, endless ways and means may be found for carrying it into effect.

It must be understood quite clearly that the tools made in this manner are by no means cheap tools on first cost. Fitted into heavy die sets and built up of many parts requiring great detail accuracy to ensure correct assembly, a large amount of grinding work is involved, and the cost is bound to be high. On the other hand, the built up construction reduces maintenance costs, and the heavier design together with stiffer presses gives a longer tool life.

By combining operations in the one tool, the cost of secondary tools is avoided, and by avoiding the secondary operation the additional first cost of the tools is quickly liquidated provided always that the volume of work is sufficient.

In conclusion, I should like to acknowledge the courtesy and friendliness extended to us by the staffs of the various houses visited. Opinion was freely given and as freely asked with the greatest courtesy. At the same time, I would ask you to remember that the picture drawn is merely a brief outline of things seen and heard. many of them obviously inapplicable under British conditions, yet containing in themselves ideas which, if adapted and modified to suit our own methods might result in considerable advantage

Discussion

MR. E. D. COLE : I feel sure that those good features which Mr. Clarke observed during his survey of American manufacturing technique will be used to the advantage of this country and Empire.

The energy displayed and the ground covered during the visit must have been extensive, and we thank Mr. Clarke for a very interesting paper. I feel that the members will be glad to take part in a healthy discussion on the paper.

The production problems of America are themselves vast, but on this point we must bear in mind that America herself is at the moment suffering considerably from her inability to stabilise or control the effects of high production methods. Furthermore, the unstable condition of finance, coupled with production, has led to a consistent request for internal reconstruction. This has led to the introduction of better control, the application of labour hours, and the useful employment of organised bodies or societies similar to the production engineers in this country.

I should like to raise the question of the relative value of the production engineers in America and in this country.

I do not suggest that the following figures have immense bearing on the problems outlined in Mr. Clarke's paper. Nevertheless, the population and area of country served must not be overlooked. The area of Great Britain and Ireland is 95,030 square miles, and the population 44,000,000.

The area of U.S.A. is 3,738,000 square miles, or if we compare America as a continent for the sake of absorbing commerce, we must include Canada and South America, making a total area of about 14,800,000 square miles with a population of 250,000,000. The result is that problems of mass production can be dealt with in a very different manner from that adopted in this country.

Reliability becomes a very important feature in this vast commercial programme. No doubt, there is much we could learn which would help us on our Empire servicing problems.

There are many questions I should like to raise with Mr. Clarke. Among these are : the question of types manufactured and how frequently changes are introduced ? The method employed for starting up of new types, and the organisation which handles the manufacture and replacement of spares for past types ? Did Mr. Clarke find that the mixed racial problem and the style of living give rise to very careful organisation in production methods ?

Is the production engineer expected to give detailed considera-

tion to the problems of export programmes in planning his manufacturing programme ?

Once production has been established on a highly efficient basis and a good profit margin on works costs has been maintained, is a proportion of these profits passed back to the production engineer for development of production problems and improvement of plant.

Relating now to the understanding of the mechanising system in America, did Mr. Clarke in his survey find as a general plan that the men handling the problems, which in turn were handed back to the production engineer, were practical men who could speedily relate the necessary action between the Executive personnel and the production people ?

Finally, as I feel I have taken a considerable amount of time, would Mr. Clarke, from his survey, suggest that the American has reached an age where he accepts mechanisation as an achievement to fulfil the requirements of moderate priced luxuries which are within purchasing range of the personnel employed as operators or employees, so that the purchasing conditions rising from the methods employed permit them to enjoy all such features to a greater extent than we are inclined to expect in this country.

MR. CLARKE : I am afraid Mr. Cole has set me a few posers. You will remember that I prefaced my remarks with " I make no claim to be unduly familiar with American methods," but I was attempting as far as I could to give you some sort of picture of what I actually saw and heard. I will endeavour so far as I can to answer the points which Mr. Cole has raised.

With respect first of all to the hours of work, it seems to be quite universal that no-one works on Saturday except the departmental stores and the shopping centres. Saturday seems to be the regular shopping day for everyone. The normal working day closes usually at four or half-past in most of the places which I visited.

With respect to the relative value of the production engineer. From the limited observations I was able to make—and one must bear in mind of course that much of my time there was spent in contact with them so that I am possibly prejudiced in favour of the production engineer—I certainly did form the opinion that he has, if I may put it that way, a little higher status in the States than he has here, and so far as I could see was looked on as a member of Society of perhaps a little more value than that at which he is taken in this country.

Now with respect to the relative size of the demand, Mr. Cole raised a very obvious point. As Mr. Puckey said, what I was doing was more or less painting a picture of the production engineer's paradise. They certainly have a very great demand over there for a large range of goods, and are in the lucky position of being able to lay out for very large quantities and to exploit the mass pro-

duction idea to a far greater extent than we can. One does notice and here incidentally I may be touching on Mr. Cole's last question, that in every factory one cannot help being impressed by the size of the car park. Practically all the people who work in factories come to work in cars and most factories of any size have attached to them a very big car park. The man working in the shop is apparently well able to afford a car. He is not only able to afford a car, but he has a car, and to that extent I should say that in the main they are quite willing to put up with, shall I say, the working conditions of mass production, because they are able by that means to obtain goods at a comparatively cheap rate. I did notice that allowing for the relative value of money and wages a man can buy a car for half as much money as we can, and on the average their people are taking twice as much money.

I will agree with Mr. Cole that we cannot carry on mass production on the same lines in this country as they can there, but I think it is always possible to learn something from the other fellow, and although I saw a lot of things in the States which we could never be able to do in this country, because we would not have enough money to lay down the plant, we can at any rate take advantage of some of their ideas.

With respect to the question that Mr. Cole raised as to the type of manufacture and changes : that of course is vital and is tied up with everything in mass production. One sees a factory laid out to produce goods of a certain kind in immense quantities. In the sort of shop that I was trying to describe to you in the Ford establishment, when one considers that every component is tooled and equipped to the extent perhaps of 2, 3 or 4 machines in some cases for a single operation, one can readily realise that the amount of capital involved to effect the changeover is so great as to make it almost prohibitive, and changing from one design to another under such conditions must of necessity be a slow process.

With respect to Mr. Cole's question regarding the allowance for export, unfortunately I tried to say more than I had time to say, but I had an illustration there which may perhaps have answered that. They did seem to take very great care in that respect, particularly in developing new designs, but beyond that I could not give Mr. Cole any very clear answer from my observations.

With respect to money going back into the business for the development of machine tools, I should say in the main that they are doing that to a great extent. On the whole I did notice that the proportion of new machines in a shop was particularly high. Every undertaking seems to be spending quite a lot of money on development and model shops, and most factories of any size seemed to boast a Research Department of some sort ; and all those efforts must naturally mean money going back into the business.

There was one other point that Mr. Cole mentioned as to whether the problems are finally solved by practical men. So far as I could see it seemed in the main that the problems were worked out fairly effectively by practical men, but in every case, with them as with us, the financial man appeared to have had the last say.

MR. B. H. DYSON : I feel sure we must all be impressed with Mr. Clarke's impression, for we hear so much of the Americans who come over to England to look it over in a few weeks, but we have to "hand it" to Mr. Clarke who has, in a few months, looked into and through American manufacturing methods, and really seen something.

I do feel, however, that he has given us conflicting views regarding one aspect, because in the early stages of his talk he stressed that American practice was to make full use of skilled labour and also to keep the job on the move, but later on he stated that a skilled operator was used on a simple burring job, and also that the procedure of completing one machining operation before commencing the subsequent operation was followed, which would appear to result in the job standing.

Regarding the views given of the safety first officers in America, they appear to be in direct contrast to that which I have always believed in, namely, "prevention is better than cure."

I was very interested in Mr. Clarke's reference to the extensive use of setting gauges. It is a matter that has had my attention for some time, because in the average factory the number of productive hours lost pending machine set up, is colossal.

Did Mr. Clarke find that the Americans were using setting gauges on capstans and automatics such as masters or duplicates of the job to be set, that could be held in the chuck or collet in order to line up the tools.

With regard to the question of incorporating gauges in the assembly fixtures, we had an opportunity of applying this procedure a little while ago, and although the line up of dial gauges soon earned the assembly fixture the name of the "petrol pump fixture," in practice it did reduce the assembly and setting time to one third of the previous production time.

If I understand Mr. Clarke correctly he said that lead wires or electrical apparatus were connected by the process of spot welding. In the majority of cases I presume these would be copper wires, and I should certainly be interested in all the detail available on the method employed for spot welding copper wire to connections.

Just one last point, following that raised by Mr. Cole, that is the question of mixed labour. I spent some few years in the States and we found that job aptitude in relation to nationality was a very real thing. For instance, on our production profile millers, that required an operator with considerable arm reach we chose Swedish operators,

we also employed Scandinavians in our ball races department. On power press work we employed Polish operators, and on straightening, setting, and accurate assembly work we invariably chose those of German nationality. For tool making we employed men of British nationality, etc.

MR. CLARKE: I am afraid I cannot answer all your questions Mr. Dyson, but I will try, taking the last one first, where you mention mixed labour. I rather misunderstood Mr. Cole there. I was thinking of black and white, but I did notice in one shop for instance where they had all Russians in the dipping shop, and Slovaks in the polishing shop, and I was told in another factory that they preferred Englishmen and Scotchmen in their tool room, which rather bears out what you said.

With reference to you question on welding wires, those used were copper, and they were welded with a very heavy current.

I think when talking about dial gauges I may have inadvertently misled the audience. I merely said dial gauges in trying to illustrate the sort of thing I meant. It was not only dial gauges. They were using all sorts of gauges. What I was trying to illustrate to the members was that they were endeavouring to incorporate as far as they possibly could gauging means in the assembly methods, and they did seem to be getting a very great deal from this. Particularly I would mention in that connection, they seemed to be making very large use of the new form of electric gauge, with which you are no doubt familiar. They seem to be making the thing in all sorts of shapes, and using it for all sorts of purposes.

One other question you raised with regard to capstans. I did not notice very much on the autos and capstans over and above what we would call normally good practice here, except that in some shops they had means for measuring diameters rather more closely than usual, and they had done a lot of developing on the lines of gauging. You possibly know the one I mean, where one measures the continuity and diameter of bores by inserting a jet and measuring the amount of air under a given pressure that escapes at different points. Beyond that in the auto shops, and the machine shops, I would say that I did not notice a great deal more than in the ordinary English shop, and was rather impressed by the absence of optical means of measuring. There is considerably less in the way of optical measurement than in this country.

MR. KIRCHENER: I too would like to express my amazement at the amount of ground which Mr. Clarke covered in the short period of two months, and also my admiration for his courage in attempting to compress his experiences into a lecture of an hour-and-a-half, and I would like him to bear these remarks in mind if the small questions which I am about to raise happen to fall outside the scope of what he has discussed to-night.

I am not raising these points in order to illustrate what he has omitted. They are just small matters on which I would like information if possible.

In the first place he mentioned several tool rooms. As a matter of personal interest to me, are there many tool making establishments in America? In other words, companies whose business is purely the manufacture of tool room equipment and, if so, to what extent are they employed by large manufacturing concerns. Does he think that such employment would compare with conditions in this country?

Mr. Clarke mentioned that the facilities for dealing with accidents were very good, but that in one press shop he noticed very few guards on the presses. What is the comparison between the actual number of accidents that occur in the average factory over there, as compared with a similar factory in this country.

He also mentioned piecework being not very apparent in America, the tendency being to employ mechanical means as far as possible. Well, I have very little knowledge of the American people apart from the visitors one meets in this country, but the few I have met have always given me the impression that they depend very largely on some sort of incentive for their enthusiasm, and I rather wondered how they overcome that problem if they are cutting out piecework. My impression has been that if you said to a collection of American operators, "Well, look boys, if you can double the output you double your pay" the output would not be doubled but trebled.

One technical point I would very much like to agree with, and that is the question of using larger presses. I think it is a very good point indeed. It is part of my business to concern myself with press work, and in all my experience I have found that one of the causes of a great number of the troubles that people experience on press work in this country is the fact that they endeavour to do a 20-ton job on a 15-ton press, and they wonder why, as Mr. Clarke mentioned, the piercing punches break. It never occurs to them that a press can distort under excessive loading.

I raise my last question, fully realising that Mr. Clarke probably did not have time to investigate this particular point, but I think it is rather important at the moment for we are concerned, as everybody knows, very much with the production of aircraft, and although we are attempting to make aircraft in large quantities, such quantities, of course, cannot approach those needed to justify mass production methods. I understand, however, that our American contemporaries have tried many ingenious methods of dispensing with costly equipment by employing rubber and synthetic materials

as substitutes for metal in building press tools for small quantity production.

MR. CLARKE : Mr. Kirschner, I will endeavour to answer your questions as well as I can.

With respect to the making of tools by outside suppliers, yes, it seems to be done very largely, and it is usually, so far as I could see, in the hands of comparatively small firms. There are a number of firms that make a speciality of going around and more or less touting for business from larger firms or going into a large firm, seeing what work is being done, and then endeavouring to find some better means of doing the job. I was able to see one or two examples. There are quite a lot of them located in Connecticut. A great many of the firms that I went to see—I can only speak of what I saw and heard ; certainly did buy a lot of tools from outside firms.

With respect to accidents on presses and the comparative statistics, I am afraid I can tell you nothing, but I was impressed, very much impressed, but the number of presses I saw without any guards of any sort whatever.

With respect to piece work, perhaps you misunderstood my remarks slightly. What I really intended to convey was that individual piece work was likely to disappear and was giving way where they were using ordinary mechanization to group systems, or in other cases to ability rates as, shall I say, a substitute for the piece work. But I think I will agree with you that the Americans are just as human, or more so, than we are, and subject to the same impulses.

With respect to your last question on aircraft, no I did not go to any aircraft shops : but on the question you raise with respect to using rubber for press tools, etc., I certainly did see it in use in radio firms. In one of the model shops mentioned this evening they were using it for developing forms of motorcar radio sets and suchlike, and they were using a hydraulic press with a rubber platen in the same way as the aircraft people are, and it seems to be a method that has very considerable promise.

MR STEVENS : You mentioned the welding of press tools. What type of tools are you alluding to, the larger or the smaller, and actually how are they constructing these things ? You did not explain that point.

You also touched the point of building up dies : are you also alluding to building up large progression dies or smaller progression dies, or can you differentiate between the two.

Another point is on the method of guarding. You said the method of guarding, as far as I could gather, is that instead of guarding the tool you have two electric push stops, and the press cannot start until you press them both at the same time. In that case are you again alluding only to special work, or is there a general method

of using electric stops? That is an important point, because the guarding of tools in England is very, very complicated, and expensive.

There is another point. What usually is their method of feeding their stocking presses? What is the most popular method?

Just one further point. You mentioned a shop specially for salvaging work. Did you get any costs of the salvage work, because usually you find it more expensive salvaging than scrapping?

MR. CLARKE: I will endeavour to answer your questions as briefly as I can.

With respect to arc welding. The work I saw was chiefly press tools, usually for small batch work up to a weight of, shall we say, somewhere about half a cwt—that is the weight of the tool. In the main they were using it for comparatively rough construction, for instance, a steel punch welded straight to the head plate.

The dies in many cases are built up, and in some cases I saw them cutting the dies out from strip using a profile flame cutting machine. The die plate used was mild steel, and they were adding an edge by welding and grinding afterwards. They were using the method very considerably for repairing broken tools by welding, and in such work as construction work for press broke dies and that sort of thing. In the case of progressive dies welding construction was used very considerably.

With regard to electric stops—it is an accepted method of stopping certain presses, but will not conform to British standards and does not come within British Home Office requirements. I would be the last man to recommend anyone to guard a press in that way.

With respect to feeding stock in presses, in the main where there were any quantities at all they used roll feeding. There are firms which specialise in doing nothing else but making feeds for power presses. In a great many cases the firm making the power press does not make the feed. A factory orders a press from a press builder, but orders the feed from a specialist; and that seems to be the universal practice. In the main they were roll feeds and most of them were power driven. The roll stock mounts on a reel, and the reel is provided with a motor, and as the stock comes down from the reel it operates a little arm on the motor so that the motor reels off enough stock to supply the feed. When enough stock is supplied and the strip has fallen down far enough it switches off the motor, and as the press eats up the stock and the strip pulls taut again it starts the feed roll once more. You see they have many sheet rolling mills over there and can roll stock to very long lengths and big widths. One sees stock coils of 4 to 5 feet in diameter which need a fairly heavy crane for handling. Most of the stock feeders are power driven.

With respect to salvage work, I would not like to express an

opinion as to its cost. I should say it was costing those people quite a lot, but as to the rights or wrongs one could only guess.

MR. BEADLE: Have you any figures with regard to labour turnover and technical school training for training operators? I take it that in the absence of any remarks regarding female operators they do not use female operatives. Does the labour change frequently, and do they spend any time training operators?

MR. CLARKE: I was rather interested in that point at the factory which I tried to describe to you, where they spent so much effort on the personnel and provided everything they could, such as swimming baths, etc., and I did raise the question as to what the figure was, and they said 12 per cent in that particular industry.

As to the employment of girls, yes, I did see some, but to nothing like the extent to which we are accustomed to see them in this country. They employ girls on some of the light assembly work, and on coil winding work, but I did not see any girls operating machines.

In almost every case they seemed to be devoting a lot of effort to training labour in every possible way. I was rather impressed by the lengths to which they were going in endeavouring to train skilled labour.

MR. COLE: I would like, if I may, to follow up Mr. Kirschener's remarks about incentive. Is it possible, that individual incentive is being driven out of the individual into the group system by production engineers basically setting down the production times and the operation times to such an extent that it is not possible, without some exceptional skill on the part of the operator, to beat the time they set down.

MR. CLARKE: Mr. Cole, I do not think I have sufficient courage to give you a decisive answer to that, but I can quote you an instance. I can give you, shall we say, an illustration from the Ford works at Ypsilante. That is a small factory where they are making motor starters and dynamos and nothing else. They have one small factory and it is equipped for doing nothing but motor starters and dynamos of one design, and it is about as perfect an example of a chain job as one could ever dream of. It is running in approximate balance with the supplies. They are all working on the chain with every operation balanced up. When the men working on the machines have finished a piece, they hang it on the chain, and each man is expected to keep his dozen pieces on the chain. If he is a little slow at times it is too bad, but provided he averages the dozen through the day, the general balance is maintained. In this place they were certainly producing a tremendous output and no-one seemed to be working very hard. They had no piecework at all, although they were paid very high wages.

MR. COLE: I think Mr. Clarke has answered that question, be-

case there is no incentive for any one person to work harder. It is just continuity of output. Initiative is washed out.

MR. CLARKE : The place I mentioned was designed with that central thought. It was running in effect in perfect balance. So far as the operator was concerned, I should say it would be purgatory, with initiative and everything else gone. As a production unit, yes, they were producing a vast amount of work with a minimum amount of effort, but to compensate the people they were working short hours and had very high wages.

A VISITOR : I should like to ask one question. You must have paid particular attention to tool room work. Could you tell me whether the methods generally used were with electricity or gas, and whether there was any extensive use of salt baths for temperature.

MR. CLARKE : I did not have time to make many remarks respecting tools, but in the main the tool hardening equipment such as I saw, did not reach the standard we have here in England. They had a reasonable proportion of electrical equipment, but the quantity of electrically controlled equipment was relatively small. I was rather surprised to notice that the vast majority was gas heated, with no more control in some cases than a very ordinary pyrometer. There were exceptional cases, but they were comparatively rare.

MR. COLE : May I raise another point ? It is on a very important point relative to labour. With methods such as you have described and as you know them in this country, would you say the average American workman terminates the day in a state of greater fatigue than his English counterpart. I refer to men working under the ordinary conditions as *you* set them down in your paper. Are the people at the end of the day, say, more free to enjoy their leisure than our people ? Do the conditions set for them permit them to employ their leisure with a freer mind than they do in this country ?

MR. CLARKE : From what I saw I should say that in the smaller towns they are better off and in the large cities worse off. In the smaller cities such as I went to, and in the place that I endeavoured to describe, they would finish their work at 4-30 and then have a beautiful country run. Everyone seemed to have a car. The houses and other buildings around compared very favourably with anything we have at home, class for class. From the appearance of the folk and the way they set about things I formed the opinion that the man working in the shop over there is definitely better off than the man working in the shop here.

A VISITOR : Just a few brief questions. Did you notice to what extent the application of die casting was used as compared with other methods of producing articles. Was material controlled by proper examination, or did it just come through the factory and the production engineer had to make the best of what was landed ?

MR. CLARKE : Material control was extremely rigid in most cases it was controlled through a laboratory.

I saw several die casting outfits. One or two were very large ones. The use of die castings in general seemed to be very extensive, and so far as I could see seemed to be on the upgrade. I even found one man who had invented a method of producing die castings in plaster moulds. You know the way the dentist produces the mould for one's teeth. This man had made a plant for producing die castings in lots of 25, using plaster of Paris moulds, and some of his die castings incidentally could bear comparison with anything I have ever seen from a steel die. He had put in a whole plant and was accepting orders for die castings from 25 upwards. He had not overcome all his difficulties, but his efforts were quite interesting.

MR. PUCKEY (Section Vice-President, who presided) : A lot has been said this evening on the credit side so far as America is concerned. I cannot help feeling that there is a debit side as well, and while I have been for years a very keen student of American affairs, both technical and political, and I have a very great admiration for America, it is not all the land of milk and honey that one might assume from listening to the various points of view put over. One very significant fact coming out is the labour situation, in which I think we are all interested to a certain extent, and this has been very lightly glossed over this evening.

We are all very much interested in labour problems, and we have had some discussion as to whether the average American is better off when finishing the day than his English counterpart. Well, my own view, for what it is worth—and all these are personal opinions, is that the average American to-day is less satisfied at the end of the day than he was fifteen years ago, and that notwithstanding the fact that he is working many hours less. It will probably excite the envy of most people in this room because the American goes home at four and does not work on Saturdays.

In 1939, as a matter of interest, the average American worked three and a half days per week in an industrial concern, and the average wage of an American in 1939 was 12% less than it was five years ago. Well, those two facts are very significant, for although he worked only three and a half days a week he was in a much more discontented frame of mind than he was five or ten years before. He only worked three and a half days a week because there was not enough business to keep their plant working any longer. I do not know what has happened since the war started, but nevertheless in 1939, which was the last completed year, the average length of time worked was three and a half days, and that, as I said, was caused, not through pleasure, but for the simple fact that they had not enough work to use the available plant. They had mechanised the plants to such an extent that, instead of work-

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ing forty hours a week, they worked something like thirty or thirty five hours. It is a point that we Englishmen might bear in mind.

You also might perhaps know that during the past few years there has been a spate of industrial legislation, mainly with a political significance, and the result is that the average American factory worker is more or less beginning to find himself. Until a few years ago the average man in America, perhaps a Slav or Scandinavian or German, or anything other than the Englishman—it is surprising how few people with an English background there are in America when you come to think it out—was a very unimaginative sort of man. He was very virile, but at the same time he had not very much class consciousness, and he toiled away at his job for quite long hours and got very good money, but he did not realise what power he had. Nevertheless, during the past few years it has been realised that all was not well in the labour camp, and the two main unions, the A.F.L. and the C.I.O. have come into more active being. The result is that the average worker in the country is beginning to realise how important he is, and is making it very uncomfortable for his employers.

Someone asked what was the labour turnover in the average factory. So far as that is concerned I can tell you this. At the present time one of the main reasons why the average employer has to be careful about sacking men is because of an Act called the Wagner Act, which discourages an employer from dismissing a worker. Moreover, if a worker is sacked he can cause such trouble that the employer, unless he has an extremely good reason, has to take him back, and the employer is liable to heavy penalties.

Under Roosevelt's regime there has been a spate of legislation that has tended to put the American workman in a higher status, and employers are not able to do anywhere near what they used to do. At the same time it has had the effect through various social efforts, through indirect taxation and direct taxation, of making the American workman much less satisfied, although superficially he seems better off.

My feeling is that while I admire very much the extraordinary technical developments which can be seen in America, and whilst I admire the many methods which Mr. Clarke has described to us, I think the thing we have to bear in mind as production engineers is whether the methods we are adopting in this country, in our small and rather more compact and more versatile units, might not in the long run achieve the results we want with considerably less disorganisation and less expense than the methods used in America.

I will now call on Mr. Carr to propose a vote of thanks to Mr. Clarke for coming along this evening.

MR. W. G. CARR: Mr. Chairman, Mr. Clarke, gentlemen. I do not know quite how Mr. Clarke felt when he was returning after

this lightning tour, but I must oness that in trying to assimilate in one evening his very comprehensive description of what he termed his impressions, I am a little bit in the wind. I feel that considerable benefit could be derived from the very able remarks he has made to-night by subsequent study of this paper, which I hope to see very fully described in the *Journal*.

I had one or two questions that I should have liked to ask Mr. Clarke, but I am afraid it has got very late now, and I may have an opportunity of speaking to him, in which case he may consider it worth while to publish the replies, but one thing seemed to strike me very forcibly throughout the whole turn of his remarks, and that was that there must be a vastly different financial attitude to business in America from that which is shown here. I do not want to enlarge on that, because it is a subject on which one could talk all evening, but there did seem a definite undercurrent of a financial attitude which may be peculiar to the larger type of factories of which I believe Mr. Clarke was speaking, and we may have found that in the medium sized or smaller factories, their organisation and general attitude would be more in line with our own.

I am not going to waste any more time now, but ask you gentlemen to join with me in a hearty vote of thanks to Mr. Clarke for a very interesting evening.

